MARCH 14
1931

15¢
Per Copy

RADIO WORLD

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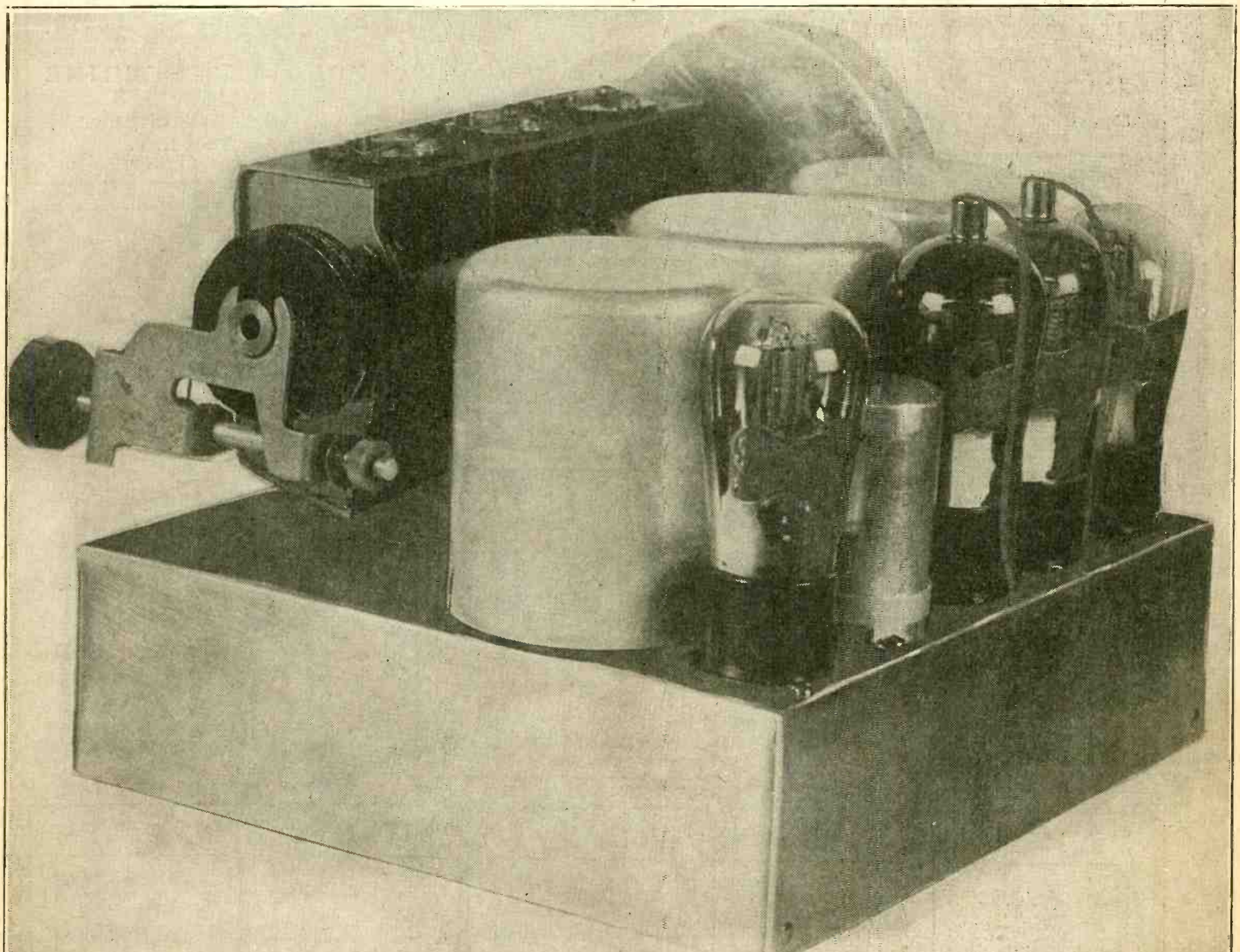
The First and Only National Radio Weekly

468th Consecutive Issue—NINTH YEAR

ALL-WAVE ULTRADYNE

Short-Wave Converter with B Supply



The Diamond AC Tuner, with Built-in B Supply. See page 19.

RADIO WORLD, Published by Hennessy Radio Publications Corporation. Roland Burke Hennessy, editor; Herman Bernard, managing editor and business manager, all of 145 West 45th Street, New York, N. Y.

The WORLD'S GREATEST *All-Wave* SCREEN GRID SUPER

ULTRADYNE

(This is the set that is described in this issue)

ULTRADYNE BOOKLET

Send 25c for this booklet which tells how to construct and operate the Ultradyne Model L-32 Receiver. This booklet also contains life-size picture diagrams and layouts of the entire set; also life-size wiring diagram of the entire circuit showing every wire location and connection.

ULTRADYNE KIT

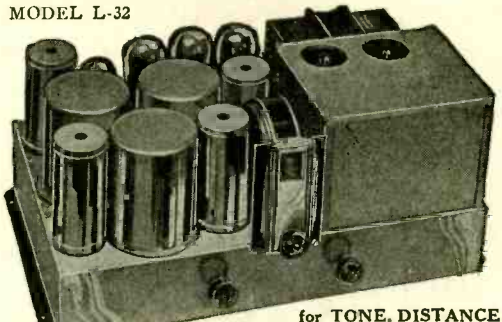
The kit contains 3 specially tested and matched Ultraformers with double compensating condensers in aluminum sealed cans, 1 special steel chassis drilled and pierced as per specifications, all ready for mounting, three rubber grommets and 4 coil mounting pillars and INSTRUCTION BOOKLET.

List Price......... **$32.50**

Operates entirely from A.C. Line
Completely Shielded Throughout
Covers All Wavelengths from 15 to 600 Meters
Tunes as easily and smoothly on the short wave as it does on the broadcast band
10 K. C. Selectivity Over Entire Band
Selectivity and Sensitivity so great, distance range is unlimited
Power Detection
Push Pull Amplification
Full Natural Tone
Not a Trace of Hum or Distortion
Steel Chassis
Simplified Construction

Mr. H. W. Duley of Brooklyn, N. Y., reports he logged 74 stations in one night.

MODEL L-32



for TONE, DISTANCE and SELECTIVITY

The model L-32 Ultradyne, with the Dynatron oscillator, works equally as well on short waves as it does on the broadcast band.

An Ultradyne receiver operating in New York City, easily tunes out WOR, Newark, and brings in WLW, Cincinnati, without a trace of interference. Likewise, WMAQ, Chicago, is brought in without interference from WEAF, New York; KGO, Oakland; KSL, Salt Lake Cty; KFI, Los Angeles; KOA, Denver; XEN, Mexico City, to mention a few, have been logged regularly. Short wave stations from all over the world have been copied on the Ultradyne Receiver.

The Super-sensitive Plio Dynatron system of radio reception responds to weaker signals than the conventional method having far greater selectivity and providing tuning ease that is unmatched. Ultradyne performance is the envy of the radio industry.

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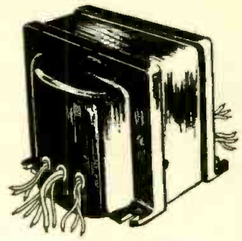
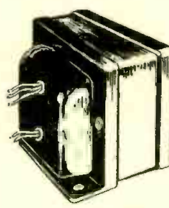
POWER TRANSFORMER, $6.00



Cat. 245-PT

THE 245 power transformer is for use with a 280 rectifier tube, to deliver 300 volts DC or 100 milliamperes, from 110 v., 50 - 60 cycles. The primary is tapped at 82½ volts in case a voltage regulator (Clarostat or Amperite) is used. The black primary lead is common. If no voltage regulator is used the other primary lead is the green one. If regulator is used, the red and black form the circuit. The winding for heater type tubes stands 16 amperes. Shipping weight, 12 lbs. Overall size: 5" extreme width x 4½" high. Polished aluminum shielded case. Order Cat. 245-PT @......$6.00

245 B SUPPLY CHOKE, $3.00



Cat. 245-CH

100 ma choke coil for B filtration in 245 circuits; 200 ohms DC resistance, inductance 30 henrys. A continuous winding tapped in two places, giving three sections and four out leads, and permitting a "choke input" to filter. By this method rectifier tube life and filter condenser life are lengthened yet filtration is splendid. The black lead goes to the rectifier filament center, the red, green and yellow leads are next in order. Capacities suggested: black, none; red, 1 mfd.; green, 8 mfd.; yellow, 8 mfd. In shielded, polished aluminum case. Shipping weight, 4 lbs. Order Cat. 245-CH @ $3.00

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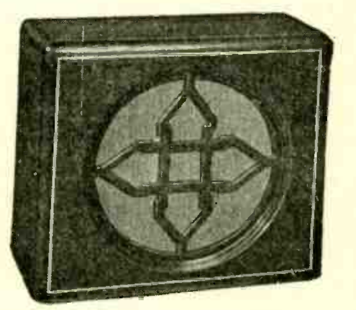

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The complete battery-operated receiver, six tubes (two 232, three 230, one 231). All parts (less tubes, less front panel) order Cat. DBR @ **$23.91**
Note: All models use same front panel. Supplied in bakelite, 7 x 12 inches, drilled for REL dial, volume control and switch, to coincide with chassis. Order Cat. DFP-Black, or DFP-Walnut @... **$1.62**

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A Converter With B Supply

By Herman Bernard

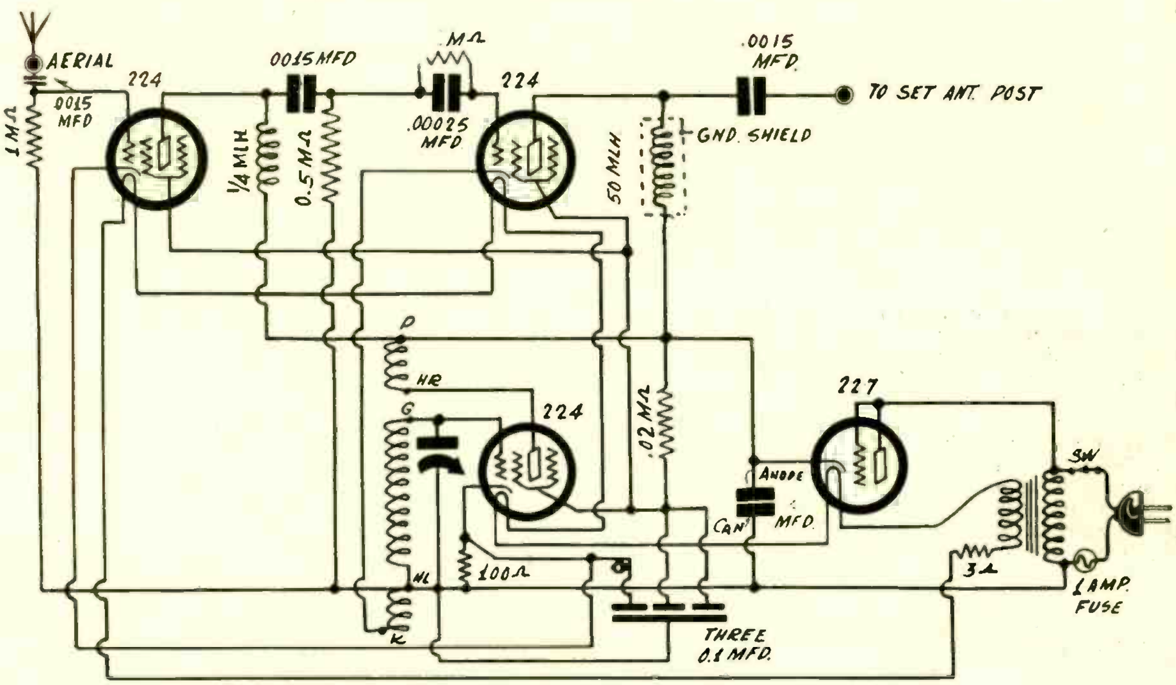


Fig. 1
The DX-4 all-wave converter, with built-in B supply. The rectifier is a 227, used in a special circuit invented by J. E. Anderson and the author. The DC voltage is about equal to the AC root mean square input. Four coils are used to cover from 10 to 600 meters.

WITHOUT using anything more than a filament transformer for power for the tubes, an all-wave converter may be constructed that has its own heater and B supply. The diagram, shown in Fig. 1, reveals how this is done in the Model DX-4 All-Wave Converter.

The converter circuit is substantially that of the No. 1-A Unit, previously described in these pages, here consisting, however, of one stage of untuned radio frequency amplification, oscillator and modulator, all three screen grid tubes. To the triple screen grid tube requirement is added a 227 tube, used as rectifier.

By joining the grid and plate elements of the 227 at the socket springs of the converter, connecting the united elements to one side of the AC line, and making the other side of the AC line the negative of the converter circuit, the cathode becomes the positive of the B supply. Direct current will flow through the circuit composed of the cathode to grid-plate path inside the tube, completed through the primary of the filament transformer and the tube plate circuits.

Resistor for Screen Circuits

Since it is necessary to provide only one other positive B voltage than the maximum, and this other is for the screens of the three tubes, a pigtail resistor of 20,000 ohms (.02 meg.) may be used, in a resistance-capacity filter circuit. The current is so small to all three screen circuits that a resistor of the grid leak type will suffice, even if only of one-half watt rating. Therefore, no voltage divider is required. If one were used, it would have to be of high resistance, say, 100,000 ohms or more, so that the bleeder current through it would be small. No current for the tubes would flow through this divider, so since a large value would be necessary to avoid putting an unnecessary drain on the rectifier, this resistor may as well be omitted.

The plate-screen current drawn by the three tubes is about 15

(Continued on next page)

LIST OF PARTS

Coils

One 1/4 millihenry radio frequency choke coil.
One 50 millihenry shielded radio frequency choke coil.
One filament transformer for series heaters.
One set of precision de luxe plug-in coils (four to a set).

Condensers

Three .0015 mfd. mica fixed condensers.
One .00025 mfd. fixed condenser with clips.
One Hammarlund Junior midline .0002 mfd. tuning condenser.
One block consisting of three 0.1 mfd. condensers.
Two 8 mfd. electrolytic condensers with brackets.

Resistors

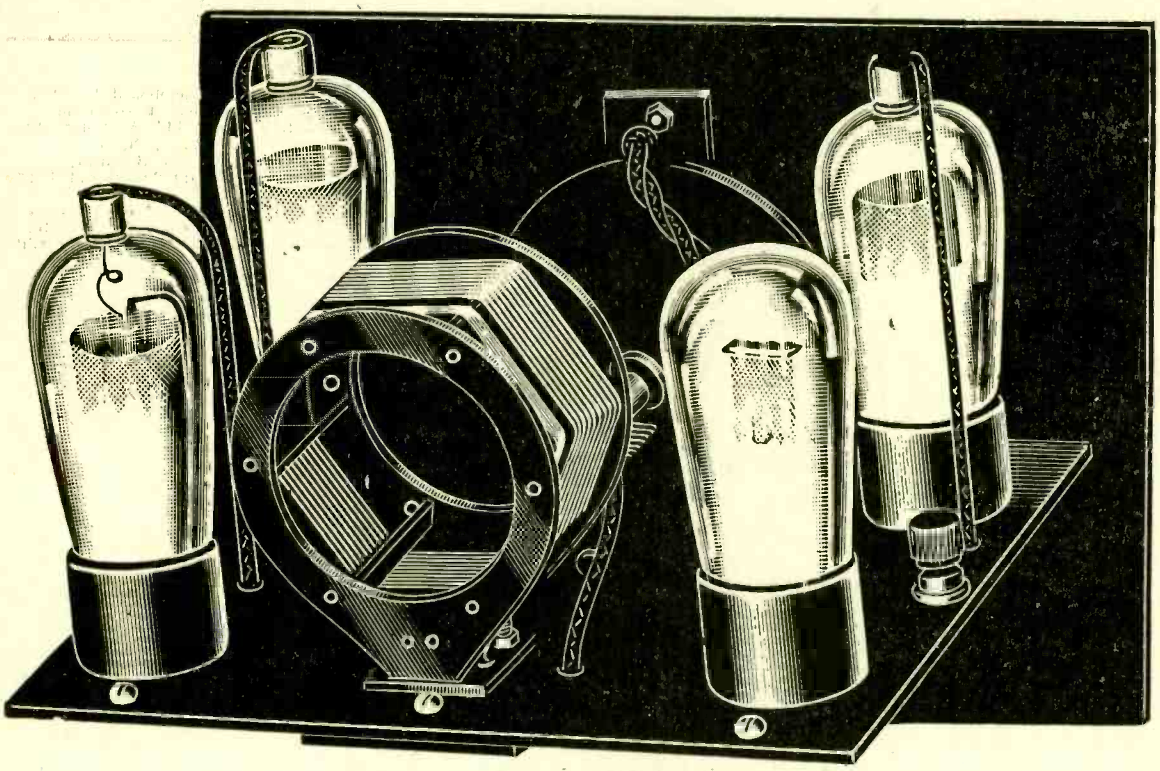
One 0.1 meg. (100,000 ohm) resistor.
One 0.5 meg. (500,000 ohm) resistor.
Two .02 meg. (20,000 ohm) resistors.
One 100 ohm flexible biasing resistor.
One 3 ohm, 2 ampere resistor.

Other Parts

One front panel 7x10 inches.
One National modernistic dial. One AC toggle switch.
One subpanel, with five UY sockets.
One 1 ampere fuse with holder.
One AC cable lead with male plug.
Two milled brass brushings for mounting grid condenser and mounting the three 0.1 mfd.
One 3/8-inch bias right angle for mounting three 0.1 mfd.
Two binding posts (for antenna input and for output)
One roll of Slide-Back hookup wire.
Three screen grid clips
Two feet of shielded wire for connection to grid clips (solder shield to B minus)
One dozen 6/32 machine screws and one dozen 6/32 nuts.

DX-4 All-Wave Converter

AC Line Voltage Introduced Directly to



The coil socket is at center rear of the subpanel while underneath are the two 8 mfd. condensers, their brackets affixed to the two screws on either side of the filament transformer. Note the symmetrical and attractive appearance of the top layout.

(Continued from preceding page)
milliamperes, which is well within the limits of the rectifier. The only objection to drawing much more current, within reasonable limits, would be the increase in the hum component. However, by keeping the drain low, and by using a high filter capacity, in this instance 16 mfd. composed of two electrolytic condensers of 8 mfd. both connected in parallel, hum is very small, even though no B supply choke coil is used. However, any who desire to incorporate a B supply choke coil may use one between cathode of the 227 rectifier and tube plate loads, one 1 mfd. capacity being used next to the rectifier, that is, from cathode to B minus, and another 1 mfd. or higher capacity from the other end of the choke to B minus.

Full Safety

The circuit is alive to direct and alternating currents, of the order of 110 volts, therefore it is advisable to use a series condenser in the aerial circuit, which stops the continuity of the direct current and, due to the relatively small capacity, acts in substantially the same manner in respect to the alternating currents. Then if a ground lead is accidentally touched to aerial, or other such circumstance arises, there will be no short circuit.

Only two connections are necessary to work this converter with any broadcast receiver. One is to remove aerial from the receiver and connect it instead to the aerial post of the converter. The other is to connect the output post of the converter by a wire to the vacated antenna post of the receiver.

It is not necessary to use a ground connection on the converter. One is on the receiver already, and is not molested. The filament transformer itself is grounded capacitatively, due to the distributed capacity between the windings of the primary and the secondary, and this suffices for the converter.

However, one side of an AC line usually is grounded, and as a result the connection of the plug to the convenience outlet becomes important, for somewhat the same reason that it is important in sets worked directly from 110 volts of direct current. The "high" side of the line, if connected to what is used as the ground side of the converter, will result in a little hum, therefore simply reverse the connection of the plug in the convenience outlet. There is no danger whatever of a short-circuit even if the plug is connected to the outlet in the wrong manner.

Makeshift Methods of Getting B Voltage

Converters that do not have their own B supply always make possible the failure to obtain satisfactory results, due to absence of adequate B voltage. Fine results are obtained from converters that do not have their own B supply, but it is necessary to know just how to obtain the voltage from the receiver. In many instances, especially those relating to factory-made sets where voltage sources are not accessible, the B voltage problem becomes serious.

One way of reacing a solution is to run a lead from the converter intended for B plus 50 volts or more, and connect directly to such voltage. This is easy in battery receivers, since 135 volts may be used, or even 180 volts. With other sets it is not always so easy, since a diagram of the set is often required, as well as familiarity with the physical means of reaching the desired point in the receiver for obtaining this voltage. Hence many queries develop, and as the diagrams of some of the circuits are not available, and moreover, even if available, knowledge of the practical layout may not be at hand, confusion sometimes results. Hence such means are resorted to in an attempt to solve the problem as the following:

1—The B plus lead from the converter is bared and looped at the far end, a screen grid tube is removed from a radio frequency socket of the receiver, the loop is slipped over the screen grid (G) prong of the tube, and the tube is put back in the set. Thus the screen voltage of the set will become also the positive B voltage for the converter. Objections to this method, from the viewpoints of both non-universality and incorrect voltages are that not all users possess screen grid receivers, and even those who do possess such sets may be confronted with altogether too low a voltage. The screen voltage in the set may be reduced from the plate voltage value by a series resistor, so the B current to the converter (actually both the plate and screen currents) must flow through this resistor, reducing the set's screen voltage, as well as the converter's B voltage. Then the set will not be as sensitive, due to lowered screen voltage, while the plate voltage to the converter may not be sufficient to produce oscillation where needed, and besides, the screens in the converter will get less than half as much voltage as will the plates, so the under-voltage conditions would be prevalent throughout, either defeating performance entirely, or vitiating it badly.

Voltage From Set's Power Tube

2—The B voltage may be obtained from a power tube for use in the converter by using a wafter adapter that consists of two circular pieces of bakelite, a little larger in diameter than the base of a tube, with eyelets in the filament holes, blank holes being punched for grid and plate, as these connections are not used. If a center-tapped resistor, say, of 100 ohms value, is placed across the filament, by connection of resistor's extremes to the two eyelets, then the center tap of the resistor may be used for positive B of the converter. The reason is that the filament of the power tube is positive in respect to ground by the amount of bias supplied to the tube. Usually there is a biasing resistor for this purpose, or, if not, the voltage divider itself has a tap to which center of the filament is connected in the set. The B voltage obtainable is equal to the bias voltage, but is opposite in utilized polarity. So, if your set has a 245 power tube there will be about 50 volts available, while if the power tube is a 171 or 171A there will be 40 volts, for the 210 only 27 volts, whereas with tubes like the 120 and 231, only 22½ volts, 112, 112A, 9 volts, and general purpose tubes, still used sometimes in the output circuit, 6 volts or so. Fair operation would obtain

Uses Simple Rectifier

227 Tube and 16 Mfd. Capacity Used

from about 50 volts, but to get any real results, the ouput tube would have to be a 250, as the bias voltage is 84 volts. Therefore the non-universality is obvious. How many sets today use the 250 power tube? Another consideration is that the B current to the converter would flow through the plate circuit of the power tube. At 15 milliamperes this would not constitute much of a strain on the 250 tube, but imagine the condition in the case of a 210 tube, when the 16 milliamperes plate current is augmented by 15 milliamperes to the converter, and equivalent or worse conditions for other power tubes, excepting the 245, where the condition is barely passable, and the 250, where it is satisfactory.

Only Universal Solution

Therefore all three ways—the direct method of obtaining the B voltage for the converter, the screen grid voltage method and the power tube filament method—do not constitute a universal solution, nor does anything save the inclusion of a B supply right in the converter.

It would be easy enough to include a regular B supply, with a big power transformer, filter chokes, condensers, voltage divider and the like, but in that instance the B supply likely would cost as much as the converter. Therefore a means was sought to provide satisfacfactory and inexpensive B voltage. The same thought had occurred to many, no doubt, but no circuit ever was presented that solved the problem as inexpensively and adequately.

Since the line is alternating current, the input to the rectifier might be taken from the line. The voltage resulting then would depend on the current drain and the filter capacity used, particularly the capacity next to the rectifier. Study of this problem, and the present necessity of solving it for converter purposes, resulted in the invention by J. E. Anderson and the author of the special rectifier included in the design in Fig. 1.

It so happens a filament transformer is used at a higher voltage secondary than ordinarily, simply for connection of heaters in series, but this is only a side issue, and the system of rectification has no relationship whatever to whether series or parallel connection is used in the heater circuits. Since the heaters are electrically independent of the radio circuit, the same secondary that supplies the radio frequency amplifier, modulator and oscillator may be used to heat the 227 rectifier.

DC Voltage About Same As AC

The DC voltage resulting from the use of this rectifier system, with 16 mfd. capacity, is practically the same as the AC input. Under load the DC voltage measured 109 volts when the AC line was 112 volts root mean square.

On the radio frequency side, the antenna-ground load selected was a resistor, the value of which is not critical, but may be 100,000 ohms (0.1 meg), since the input is then stronger than if a choke were used. However, in the plate circuit of this tube an RF choke of one-quarter millihenry inductance was selected, because it presented an adequate load for short-wave reception, even though it did reduce somewhat the volume in reception of broadcast waves through the converter. However, the small RF choke had the happy faculty of preventing the radio frequency tube from oscillating. This oscillation, normally not present in an untuned circuit like that of the first stage, evidently was due to coupling through the primary of the filament transformer.

Skipping to the output stage for the moment, the coil in the modulator plate circuit has an inductance of 50 mlh, and is of the shielded type, again for the reason of avoiding oscillation where it is not wanted.

The receiver itself, if sensitive at the high frequency end, is usually worked there for intermediate frequency, preferably at some setting above the broadcast band's frequency limit, say, 1,600 kc, because interference due to direct pickup of broadcasts will be suffered. In fact, coils are designed as to wavelength coverage with some such frequency in mind. If the set is worked at the other extreme, the lowest frequency it will tune in, say, 545 kc, then only the higher broadcast frequencies can be tuned in on the largest coil, due to lowering of the intermediate frequency increasing the frequency of response in converter tuning.

Small Coil is O. K.

Assuming, then, use of a high intermediate frequency, if high-inductance coils were used throughout the converter, in antenna, plate and grid circuits or RF and modulator tubes, the natural period of the converter's tubes (omitting the oscillator) might be so close to the intermediate frequency that the situation would resemble the adding of two stages of tuned radio frequency amplification to a receiver, which would make both the receiver and the converter oscillate at the intermediate frequency.

The diversity of choice of resistors and coils and values of coils therefore was dictated by this consideration of oscillation. No hesitancy need be felt about using the tiny RF choke coil, for in short-wave reception it approaches the ideal, while for reception of broadcast stations through the converter, it reduces the volume from what it would be with resistors throughout, or large inductance choke coils throughout, but increases the apparent selectivity, due to looser effective coupling.

These remarks, therefore, explain why some converters actually act as substantial boosters to broadcast receivers, while others seem to act as slight dampers. The coupling devices in the converter account for this, as a small choke in the line somewhere will keep the natural period of response high in frequency.

Another factor in favor of a small choke, where a choke is used other than in the output, is that response is maintained all over the dial of the converter, without dead spots which might result from the large distributed capacity of high inductance chokes serving as a bypass to higher radio frequencies, and thus preventing the reception of some of the most interesting and most distant programs.

Literature Wanted

Readers desiring radio literature from manufacturers and jobbers concerning standard parts and accessories, new products and new circuits, should send a request for publication of their name and address. Send request to Literature Editor, Radio World, 145 West 45th Street, New York, N. Y.

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A THOUGHT FOR THE WEEK

HE is the inventor of "Mechanical Mike," the giant robot that has been somewhat of a sensation at radio shows and the body of which contains more than ten miles of wire. He also is the conductor of the Toronto Symphony Orchestra, which is on the air each week. His name—believe it or not, yet incredulous ones!—is Amenhotep Khun-Aten Astyanax Erysiptolemas Luigi Paul Maria von Kunits, Edlar (Baron) von Varasdin. His parents call him "Paulie," so let the busy world wag on.

Design Requirements for

By J. E.

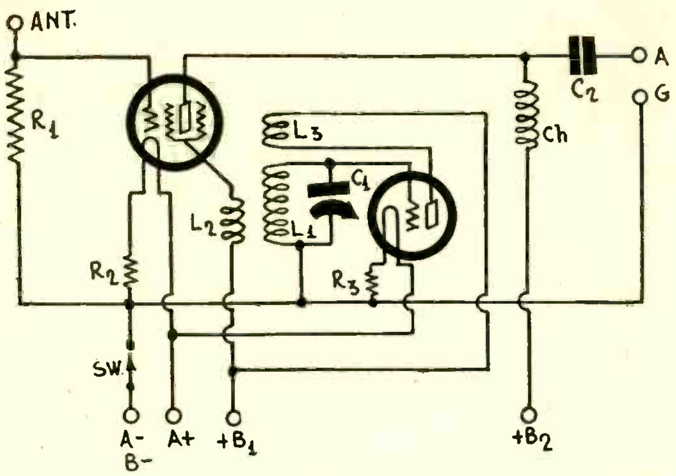

Fig. 1
A simple short-wave converter for battery tubes. The modulator is a screen grid tube and the coupling between the modulator and the oscillator is through the screen circuit.

WHAT makes a short-wave converter sensitive or insensitive? What makes it selective or not selective? What determines its tuning range? These are some of the questions that arise in connection with the selection of a short-wave converter for a particular receiver or that arise after the converter has been connected to a receiver.

The most important feature making for selectivity is the selectivity of the broadcast receiver with which the converter is used, for the converter is only slightly more selective than the receiver, and it is only slightly more selective if there is a tuner in the converter which tunes to the short-wave signal, not counting the oscillator tuner, for this has no effect on the selectivity. Hence if a short-wave converter is to be selective it is imperative that the receiver with which it is used is selective.

Sometimes the converter seems non-selective even when it is used with a receiver that is considered superselective because the receiver is tuned to a frequency at which it is not selective. For example, the receiver may be very selective at all frequencies except those near the 1,500 kc limit. Therefore when 1,500 kc, or a frequency near this, is used for intermediate frequency the converter is not selective. Such a receiver should be tuned to another frequency, say 550 kc, for then the converter would be more selective.

Condition for Sensitivity

The condition for high sensitivity is about the same as that for high selectivity, for the converter is no more sensitive than the receiver, for nearly all the amplification occurs in the receiver. As a matter of fact, there is a loss in the converter due to the frequency conversion, just as there is a loss in any superheterodyne due to the same cause.

If the broadcast receiver with which the converter is used is not equally sensitive throughout its tuning range, and the circuit is set where the sensitivity is low, the converter will be insensitive. Therefore the broadcast receiver should be tuned to the frequency at which it is most sensitive.

If these two conditions, that is, the condition for greatest sensitivity and greatest selectivity are inconsistent, it is necessary to compromise between sensitivity and selectivity. Fortunately, most broadcast receivers are such that where the selectivity is greatest the sensitivity is also greatest, because lack of selectivity and sensitivity are usually due to lack of adequate tuning so that when the tuned circuits are all lined up to the same frequency both the selectivity and the sensitivity are at their maximum.

It cannot be emphasized too strongly that the selectivity and the sensitivity of the converter are primarily the same as the corresponding characteristics of the broadcast receiver converted to a short-wave set.

Bringing in the Short Waves

But it by no means follows that any converter is just as good as any other on the same broadcast receiver when this is tuned to the same frequency. It is easy to throw away the feeble short-wave signals, and it is not impossible to strengthen them or to conserve them. In the design of a short-wave converter it is necessary to consider many points, such as proper coupling between the antenna and the radio frequency amplifier or modulator, proper coupling between the oscillator and the modulator, most efficient detection in the modulator, and efficient coupling between the modulator and the broadcast receiver. It has been found that one of the weakest links is the coupling between the converter and the broadcast receiver because there are so many input devices in different receivers.

Aside from sensitivity, the one necessary condition for success is that the oscillator oscillate. If it does, some signals are sure to be brought in no matter how unfavorable are all the other conditions. And if the oscillator does not oscillate, nothing can be done to the converter or the broadcast receiver that will bring in short-wave signals, except something that will bring about oscillation. The oscillator is the heart of the circuit and if that stops, the set is dead. It may bring in broadcast stations, but this is in spite of the converter, not because of it. The first rule in getting short-wave signals with a converter is to make it oscillate.

Effective Input Coupling

It is important to get an effective coupler between the antenna and the converter's first tube. Uniformly effective is a high resistance such as R1 in Fig. 1. It does not really make much difference what the size of this resistance is for values between 10,000 and 1,000,000 ohms seem to give about the same results. Theoretically, the higher the resistance the higher the sensitivity, but practically there is little difference when the resistance is over 10,000 ohms. However, it depends somewhat on the length of the antenna, but we are speaking of average broadcast antennas.

There is a disadvantage in the uniform effectiveness of the high resistance coupler and that is the fact there is no frequency discrimination. If there were it would not be uniformly effective. The resistance is just as effective at audio frequencies as it is at the highest radio frequencies. Indeed, it may be more effective at the lower frequencies. Hence the resistance coupler will bring in more noise than one containing reactance. We could substitute a choke coil for the resistance R1. But if we do that we have to make it large to be effective on the low frequencies in the neighborhood of 1,500 kc. And if we make it large it may not be a choke at all at the higher frequencies, but a by-pass condenser. If we make the coil small so that it is effective at the higher frequencies it may not be at all effective around 1,500 kc. Hence we have to compromise. If we make the choke one millihenry it will have nearly 10,000 ohms at 1,500 kc and therefore the coupler will be just as effective as if it were a 10,000 ohm resistance. At 20,000 kc, 15 meters, this choke will have an impedance of about 126,000 ohms, provided that the distributed capacity is negligible, and this would make the coupling more effective at the higher frequency in view of the fact that the input capacity of the tube alone may be at least 5 mmfd., the coupling is likely to be exceedingly small at 20,000 kc.

Input Capacity Effect

It is not to be supposed, however, that the effect of the input capacity is negligible when a resistance is used. As the resistance R1 is increased the input impedance approaches the impedance of the input capacity and it also approaches that value as the frequency increases. It would seem that the most effective coupler would be a tuned circuit. This suffers from the disadvantage that another control is required, and most people object to controls these days. They would rather add a lot of tubes in the circuit to avoid a knob on the panel.

Of course, when a tuned circuit is used, a set of plug-in coils is needed if the converter is to cover the entire short-wave band. This is another objectionable feature to some fans. But since the oscillator coils must be switched, it only takes a second longer to switch the RF coil also.

Coupling Oscillator to Modulator

One very important thing is correct coupling between the oscillator and the modulator. There are many ways of coupling the two but the degree of coupling must be right or the circuit will not function properly. If the coupling is too close, there will be overloading of the modulator and a great deal of noise in the output. If the coupling is too loose, the sensitivity will not be good for a given broadcast receiver. Close coupling also produces interference aside from other undesired noises. There is also danger of the tuned circuits interlocking when the coupling is close and there is a tuned radio frequency in addition to that of the oscillator. When there is interlocking the oscillator usually stops functioning, the radio frequency circuit acting as a trap. When this occurs the circuit becomes dead in spots or all over the dial.

Interlocking of the tuned circuits often is caused by stray

Short-Wave Converters

Anderson

coupling rather than by the intentional coupling through the pick-up, so in some instances it is necessary to shield the circuits. If no shielding is done the two tuned systems must be far apart.

In Fig. 1 there is only one tuned circuit, that of the oscillator, and therefore there is no danger of interlocking. However, if R1 is replaced by a tuned circuit precautions must be taken. In this circuit the pick-up coil L2 is connected in the screen circuit of the modulator tube. It could also be put in the plate or grid circuits without affecting the net results, provided that the number of turns on the pick-up coil is adjusted to suit the position in which it is placed. If the pick-up is put in the grid circuit not nearly as many turns are needed as when it is placed in the plate circuit, and when it is placed in the screen circuit the number of turns required is intermediate. When the grid circuit of the modulator is tuned it is well not to put the pick-up coil in that circuit because interlocking may occur. If the modulator tube is of the cathode type, the pick-up coil may be put in this circuit.

Efficient Modulation

Modulation is the same as detection, except in the point of view, and if we make the modulator tube an efficient detector we achieve our purpose. We may resort to either grid bias or grid leak detection. It does not make much difference which.

While the grid leak detector is normally more sensitive than the other it also overloads more quickly. The output of the grid bias modulator may be considerably larger than that of the other when the overloading point is reached, and we can overload either detector with the oscillator. There is really very little choice between the two detectors. In Fig. 1 grid bias is shown.

When a screen grid tube is used as modulator it is simply a question of getting the right combination of grid, screen, and plate voltages to get the optimum conditions for detection. Two of these voltages may be the same as for amplification with the tube in question and the other may then be varied until the detection efficiency is optimum. The particular circuit determines which should be varied. As a rule it is easier to vary the grid bias.

If the tube is a heater type the screen and grid voltages may be varied simultaneously by means of a potentiometer P as illustrated in Fig. 2. This is a very convenient method. While it is not necessary to put the potentiometer on the panel it is a good volume control and if placed there can be used for this purpose. This method is not available for filament type tubes.

In case the modulator tube is a 227 the potentiometer method may be used if one end of it is connected to the plate return instead of to the screen return.

Output Coupler

The coupler between the converter modulator and the broadcast receiver is an important part of the circuit, for it may either make the combination sensitive or relatively insensitive, and this part is the most troublesome because there are so many different inputs to broadcast receivers. It has been found that if the input to the receiver is untuned the results will be very poor, but if it is tuned, whether there is a primary winding or not, the results are generally good. If the broadcast receiver is a superheterodyne, the results are not quite as good as one would expect with such a sensitive receiver, although generally satisfactory.

In Fig. 2 the output circuit of the modulator is tuned, and this coupling is more effective when the input to the receiver is untuned, except when the stopping condenser C10 is made very small, when the converter works well into a receiver having a tuned impedance input. The reasons are obvious when one considers that there are two tuned circuits, the two acting like a band pass filter. When the converter output is like that in Fig 2 and when the input to the receiver is a transformer with a small primary, it is better to put a small winding on coil L and form a link circuit of this small winding and the primary in the receiver. When the input to the receiver is a resistance or choke coil, the connections should be as in Fig. 2 without any changes.

One difficulty with tuning the output of the modulator tube is that there will be two tuning controls in the intermediate amplifier, one C9 and the other the tuning control in the receiver. This is only a disadvantage when it is desired to change the intermediate frequency from time to time. There are many occasions when this is desirable.

The tuned output also has the advantage of eliminating broadcast stations near the frequency selected for intermediate. The more sharply the output circuit is tuned the more complete is this elimination and it is usually possible to select a frequency in the broadcast band without meeting interference. However, if the lead from the converter to the receiver is long there will be some interference from this source.

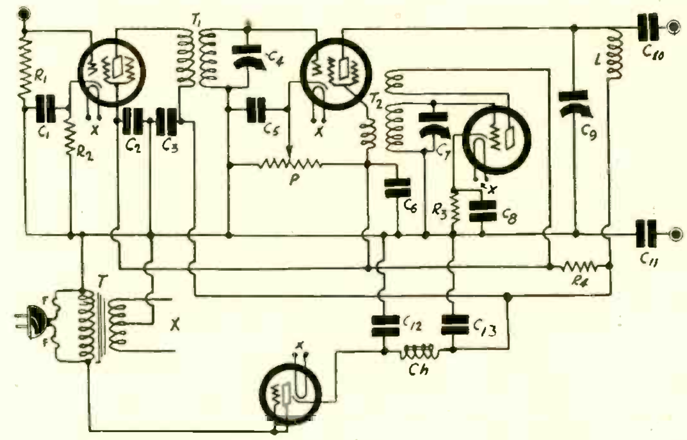

Fig. 2

A four-tube short wave converter with a stage of RF ahead of the tuned modulator and with a built-in power supply. No intermediate frequency stage is built in with this converter.

A Common Complaint

It is a common complaint that when the converter is connected to a set, broadcast stations come in all around the intermediate frequency. For example, if the intermediate frequency is set at 1,400 kc stations all the way from 1,500 kc to 1,000 kc come in. This means only that the broadcast receiver is not selective. The tuner in the output of the converter helps in cases of this kind. The tuner also helps to increase the effectiveness of the modulator by providing a by-pass condenser for the higher frequency currents.

When there is insufficient amplification in the broadcast receiver it is best to put in a stage of IF in the converter. In that case it is best not to tune the output of the amplifier because this might upset the stability of the broadcast receiver. A choke coil and a condenser are sufficient for output coupling. The output circuit would be like Fig. 2 with the condenser C9 omitted and the coil L being a choke in place of a small tuning coil. The tuned circuit between the modulator and this amplifier should be retained.

Radio Frequency Amplifier

The circuit in Fig. 2 has a stage of radio frequency amplification ahead of the modulator. Although the tube is a screen grid tube the amplification in this stage is not very great but it does help to increase the sensitivity a little. Perhaps the main advantage of this tube is that it removes the radio frequency tuner from the antenna so that the tuner is the same regardless of the characteristics of the antenna that is used.

The main reason for the amplification in this stage is that the input is untuned, as was explained under Fig. 1. That is, the grid to cathode capacity of the tube partly short-circuits the input impedance. It should not be assumed that to get greater amplification the input to this tube should be tuned, because another tuner at radio frequency would require another set of short-wave coils and another tuning control. Moreover, it would be practically impossible to stabilize the circuit. One tuner at radio frequency is sufficient.

The Power Supply

If the tubes in the converter are of the AC type the filament transformer should always be built in for otherwise long, heavy leads would have to be run from an external transformer and the voltage drop in these leads may be excessive so that the filament current would not be high enough to operate the circuit properly.

It is also convenient to build in the B supply in the converter, unless batteries are to be used, and they are not the most convenient by any means. Taking the B voltage from the receiver is not always easy. In fact, in most commercial receivers the proper voltages are not accessible.

It has been found that a B supply like that illustrated in Fig. 2 and 3 gives good results. It consists of a 227 tube used as a half-wave rectifier, the AC voltage for rectification being taken from the primary of the filament transformer, or directly

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How to Pep Up Converters

Input and Output Circuits Important Factors in the Sensitivity

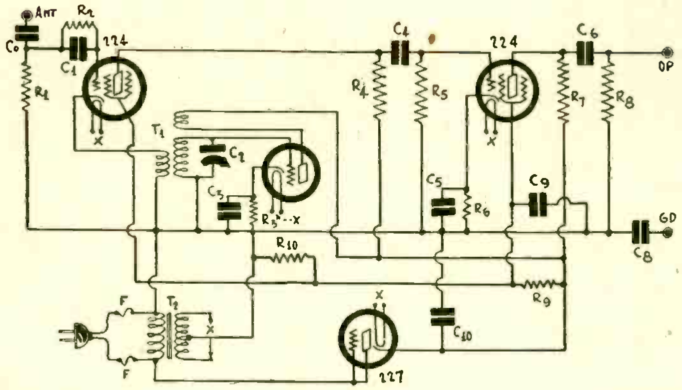

Fig. 3

Another four-tube short-wave converter with built-in power supply. One stage of untuned intermediate frequency amplification is used. A circuit like this is not as satisfactory as the one shown in Fig. 2.

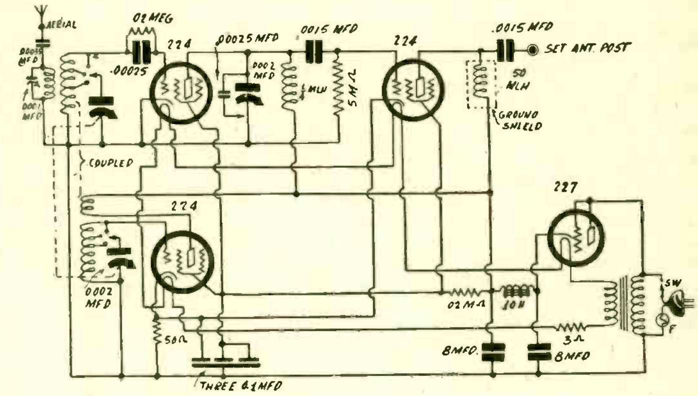

Fig. 4

A four-tube short-wave converter with built-in B supply, tuned input, and a tuned coupler between the modulator and the intermediate frequency amplifier. The pick-up here is by induction between the oscillator and the modulator tuners, no special pick-up coil being used.

(*Continued from preceding page*)

from the 110 volt line. If the current drawn from this rectifier is small, the rectified voltage will be around 110 volts, or even more, which is sufficient to operate the tubes in the converter, even when some of them are screen grid tubes, as in the case of Fig. 2.

A half-wave rectifier requires considerable filtering to remove the ripple. While a large electrolytic condenser of about 8 mfd. would be enough, it is preferable to use two 4 mfd. condensers C12 and C13, and a choke coil Ch. Of course, if the condensers are made larger than 4 mfd. the filtering will be better. A 30-henry choke is quite sufficient.

The voltage divider in this circuit consists of R4 and the potentiometer P. If the resistance of P is 30,000 ohms, that of R4 should be about 12,000 ohms.

Line Protection

A low-current fuse F is placed in each side of the primary of the filament transformer as a precaution against possible short circuits. Another precaution is a condenser C11 in the ground lead that is to be connected to the broadcast receiver. Still another precaution is a condenser in the antenna lead, as Co in Fig. 3. The reason for these precautions is that the converter may be alive to the 110 volt AC by virtue of the direct connection of the rectifier to the line.

Fig. 3 illustrates another four-tube converter with a built-in B supply of the same type as that used in Fig. 2. In this the filter does not have a choke coil but only a large electrolytic condenser C10. The use of a choke is recommended even if the condensers have to be reduced in size and capacity.

Fig. 3 illustrates the method of coupling the oscillator to the cathode as was mentioned previously. This has been found to be a very effective method of coupling when the modulator tube is a 227 or a 224. It also simplifies the oscillator coil in that only five terminals are required for the three windings. Hence a UY type plug and socket may be used for the oscillator coils. This is also true when the scheme in Fig. 2 is used, although the coils are not interchangeable.

Grid Leak Detection

In Fig. 3 grid leak and condenser method of detection or modulation is used. It works all right for either a screen grid or a 227 tube, but the constants are somewhat different from those used when the tube is used for converting the signal to audio frequency. The condenser may be smaller and the grid leak should be considerably smaller. For example, 20,000 ohms often gives better results than 2,000,000 ohms.

There is no by-pass condenser in the plate circuit of the modulator tube in Fig. 3 because the output capacity of the tube is quite large in view of the fact that the intermediate frequency used is in the broadcast band, or above that band, and also in view of the high resistance R4.

Resistance coupling is indicated in Fig. 3, but there are several reasons why this cannot be recommended. In the first place the input and output capacities of the tubes are across the grid leaks and the plate resistances, and these capacities reduce the coupling impedances to the point where the coupling is ineffective, especially when the intermediate frequency used is at the 1,500 kc end of the broadcast band.

Another reason is that the circuit is not selective and it acts as an antenna. Hence when a converter of this kind is connected to a broadcast receiver the input at all frequencies is quite high and it may be that the broadcast receiver is not selective enough to segregate the frequencies. In other words, interference is likely to be severe with this kind of amplifier, for the selection is imposed entirely on the tuner in the broadcast receiver.

Low Current Advantage

The advantage of the resistance coupling in the converter is that the current drawn from the B supply is extremely small and therefore the voltage is comparatively high. The current is so small that it may be said without exaggeration that the only current is that required by the oscillator tube and the voltage divider. High voltage alone, however, is of little avail if the coupler is such that the signal is not amplified.

If the proper coupling between the modulator and the broadcast receiver is used it would be just as well to omit the second tube, unless tuned circuits are used as suggested previously.

Use of By-Pass Condensers

By-pass condensers should be used liberally in a short-wave converter, as well as in broadcast receivers, to keep the radio frequency currents out of common parts of the circuit and to avoid feedback, both regenerative and degenerative. Thus in Fig. 2 each grid bias resistor is shunted by a condenser, C1 for R2, C5 for the bias section of P, and C8 for R3. Without these condensers there would be a certain amount of reverse feedback in these tubes which would lower the sensitivity. The screens are also by-passed by C2 and C6. These condensers serve to steady the screen voltages and at the same time to keep the signal component of the screen current out of the B supply.

C2 and C6 also serve the oscillator and thus help to minimize the stray couplings between the oscillator and the modulator. The larger these condensers the better, but 0.1 mfd. for each is about as large as they need be. This applies also to the grid bias condensers. The reason these condensers are large enough is that the lowest frequency involved is that of the intermediate, which is not lower than 550 kc.

Different Types of Converters

The points discussed in the preceding paragraphs apply to any type of converter and not only to those illustrated in Figs. 1 to 4. They point to what might be said to be an ideal converter. First, such a converter should have a built-in power supply, both filament and plate voltages. Second, the input should be tuned to the desired signal. Third, the output circuit of the oscillator should be tuned and there should preferably be a stage of intermediate built in with the converter and the tuner of the intermediate coupler should have the same range as that of the broadcast receiver.

The circuit in Fig. 4 incorporates most of the desirable features of a good short-wave converter. It has a tuner in front of the modulator to help increase the selectivity and the sensitivity, it has an efficient type of detector, and has a circuit tuned to the intermediate frequency and this is followed by an intermediate frequency amplifier. The filtering in the B supply is also more complete than that in the others, having two condensers across the line and a choke coil in series.

The output coupler in this circuit is well adapted to broadcast receivers having large primaries in the first tuned circuit or those having high impedance inputs. Getting the proper pick-up or coupling between the oscillator and the modulator is only a matter of placing the two coils at a suitable distance apart.

"Proceedings" Reviewed

Synchronized Operation Analyzed and Condenser Speaker Described

Review of papers appearing in the February issue of "Proceedings of the Institute of Radio Engineers."

"ON the Simultaneous Operation of Different Broadcast Stations on the Same Channel," by P. P. Eckersley. This paper gives a detailed account of experiments in the operation of several radio broadcast stations on a common frequency, conducted in England. The theory involved in synchronous transmission is set forth and an account of tests given. It was found experimentally that "when the stations were perfectly synchronized, then, service area conditions could be said to exist at any point, provided the field of one station at that point was more than five times the field strength of the other station at that point and provided each station radiated the same program." When two stations were operated at constant frequencies differing by 10 cycles per second it was found that "service area conditions of one station could be said to be bounded by a field contour which was everywhere ten times greater than the interfering field from the other station provided each station radiated the same program."

One conclusion reached regarding conditions for successful single wavelength working was that "it is quite impossible to expect to set up any successful single wavelength system (wherein the stations are reasonably close together) if different programs are radiated by stations sharing the same wavelength." He emphasizes the conclusion that "Single wavelength operation must rely upon the radiation of the same program by all stations sharing the same wavelength if the system is to be successful."

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Hans Moegel, Transradio A. G., Berlin, Germany, describes "Some Methods of Measuring the Frequency of Short Waves." He gives four different methods for practical frequency measurements on short waves (10-50 meters, 30,000-6,000 k.c.) with an absolute accuracy of plus or minus 0.01 per cent to plus or minus 0.001 per cent and a relative accuracy of plus or minus 0.0001 per cent. Harmonic overtones are used in each method and the frequency standards are exclusively the luminous quartz resonators developed by Giebe and Scheibe. Diagrams of the circuits used in the measurements are given.

The same author contributed a paper on "Monitoring the Operation of Short-Wave Transmitters," a discussion of all the methods of monitoring the variations in the radiated high-frequency energy which occur in the operation of short-wave transmitters which have been used in the five years' experience of the great Nauen radio stations for overseas wireless communication. Experience has shown that all monitoring can best be effected when the monitoring equipment is centralized, when only one or two attendants are needed.

* * *

Joseph Sahagen, Standardizing Laboratory, General Electric Co., West Lynn, Mass., discusses "The Use of the Copper Oxide Rectifier for Instrument Purposes." Advantages and disadvantages of this type of meter are pointed out, the characteristics relating to temperature and frequency are given, and the effect of wave form explained. Schemes for compensating for temperature and frequency errors are given. The full-wave Copper-Oxide rectifier is recommended and such an instrument when properly constructed can be relied on to an accuracy of one per cent provided the wave form is pure. The main advantage is that the sensitivity of such meters is much greater than that of any other rugged AC instrument.

* * *

G. D. Robinson, U. S. Naval Academy, Annapolis, Md., contributes a paper entitled "Wide Range Scales for Fading Records by Electrical Means." The intermediate frequency amplifier, part resistance and part tuned coupling, is shown together with the output device for recording the signals. The second detector consists of two 240 tubes connected in push-pull on the radio frequency side and in parallel on the audio side. A bridge arrangement containing two additional 240 tubes is used to prevent drifting of the resistance coupled amplifier. Two 250 tubes in parallel work into the recording device.

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Of special interest to radio fans is a paper by P. E. Edelman, Electrical Engineer, Chicago, Ill., on a "Condenser Loud-speaker with Flexible Electrodes." Detailed description of the speaker is given, including the structure and treatment of the flexible diaphragms and the frames holding them. A method of baffling the diaphragm is also suggested. Several polarizing circuits suitable for the speaker are also shown diagrammatically.

"The conclusion is advanced that the departures in structure discussed have brought the flexible condenser speaker to a stage where it can compete with the other best known types of reproducers, that in some respects it has distinctive advantages in quality of reproduction, and that further advances may be attained along this line by the development of amplifiers with vacuum tubes designed to fit the characteristics of the condenser speaker."

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W. W. Kenrick, Consulting Engineer, Bureau of Standards, A. H. Taylor, Naval Research Laboratory, Bellevue, Anacostia, D. C., and L. C. Young, also of the Naval Research Laboratory, report a "Note on High Frequency Transmission During the Summer of 1930." It is a study of echo signals.

* * *

Lloyd Espenschied, American Telephone and Telegraph Co., and William Wilson, Bell Telephone Laboratories, New York, contribute a paper on "Overseas Radio Extensions to Wire Telephone Networks." They outline the principal circuits and point out that they fall in five main groupings, namely: The North American-European connections; North America-South America; South America-Europe, Europe-Africa, Asia, and Oceania; and North America-Pacific points and the Far East. A section is devoted to a discussion of short-wave technique and others to transmission results, magnetic storms, the problem of the transmitting medium, and planning the international use of frequencies.

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John W. Arnold and Paul F. Bechberger, Western Union Telegraph Co., solve the problem of "Sinusoidal Currents in Linearly Tapered Loaded Transmission Lines." The paper is mathematical.

RCA Announces New Variable Mu Tube

The RCA Radiotron Company has announced a new screen grid tube, the RCA 235, for use in radio-frequency and intermediate-frequency amplifiers in circuits especially designed for it. The new tube is of the variable mu, or variable mutual conductance type. It is particularly intended for the reduction of cross modulation and permits a wide volume control without the use of local-distance switches or antenna potentiometers, making it adaptable to automatic volume control design. The cathode is of the quick heater type.

Tentative ratings and normal characteristics for the RCA 235 are as follows:

Filament voltage	**2.5 volts**
Filament current	**1.75 amperes**
Plate voltage (recommended)	**180 volts**
Screen voltage (recommended)	**75 volts**
Grid voltage, negative bias	**1.5 volts**
Plate current, milliamperes	**9**
Screen current (milliamperes)	**3 or less**
Plate resistance, ohms	**200,000**
Mutual conductance, micromhos	**1,100**
Grid to plate capacity (maximum)	**0.010 mmfd.**
Input capacity	**5 mmfd.**
Output capacity	**10 mmfd.**
Length, inches	**5.25**
Diameter, inches (maximum)	**1 13/16**
Socket, UY	

NEW BOOKS

Short Waves, by Charles R. Leutz and Robert B. Gable; ten chapters, 370 pages, 6x9 inches.

This is one of the most complete and up-to-date books dealing exclusively with short-wave reception and transmission. The book first gives a brief historical review of radio development leading up to the use of short waves. Then it takes up the principles of short-wave propagation and goes into the practical phases of commercial radio telephony and telegraphy, showing the circuits used both for transmission and reception. Other subjects treated in detail are: Ship to Shore Telephony, Directional Antennae, Television, Aircraft Radio Equipment, Short-wave Broadcast Receivers, Ultra-Short Waves (Medical and Surgical Applications), and Amateur Short-Wave Equipment. The book is copiously illustrated with schematic diagrams and photographs.

Power Amplifier for Television,

By Feodor

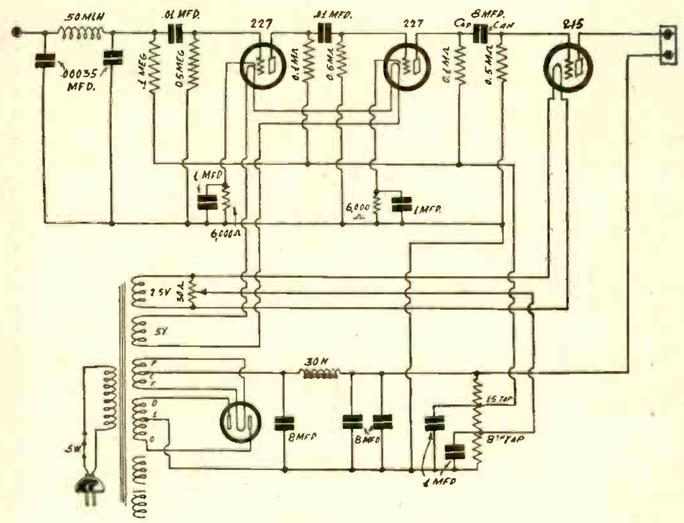

Fig. 1
The power amplifier with constants specified. B minus is usually grounded.

THE growth of interest in television reception has increased the popularity of resistance-coupled audio amplifiers, because these are found to give the best definition of images. While the circuit is familiar, the values of constants have to be chosen so that the amplifier will possess stability.

Once the amplifier is functioning properly, of course it is useful for television work and for magnification of the output of the detector of any type of tuner, including a broadcast tuner, and for phonograph pick-up. Therefore the audio power amplifier, as diagrammed, provides heater current not only for its own tubes, but also for tubes in a tuner.

Since the power amplifier is to be used for broadcast and phonograph work, as distinguished from television, the filtration must be excellent, to eradicate hum. The television signal is not so much influenced by static and other interference, including hum, but the broadcast receiver and pick-up are greatly affected thereby, hence the pains taken to provide filtration of the highest order.

Capacities Used

The solution lies simply in the choice of large filter capacities, and an adequate B supply choke. The capacity next to the rectifier is 8 mfd., while that in the "reservoir" position, across the voltage divider, is 16 mfd., composed of two 8 mfd. capacities in parallel. The condensers are electrolytic. The B supply choke coil has a commercial rating of 30 henries.

It will be noticed, also, that an 8 mfd. condenser is used for isolating the plate of the first audio tube from the grid of the 245 output tube. This is unusual, since it is generally true that the capacity of the isolating condenser, if large, will tend to introduce motorboating. However, an experimental connection of a large condenser in the position shown proved an excellent volume-booster, without introducing any instability. The leakage through the electrolytic condenser, although very small, bucks any grid current that may be flowing in the power tube. This results in a stabilizing action, and the effective mu of the 245 tube is increased. It was found that the gain in amplification was more than 30 per cent.

Others may have tried a large capacity as isolating condenser in resistance-coupled audio amplifiers, as this system was outlined for the first time in the February 21st issue of RADIO WORLD. Then a two-stage amplifier was shown. The object of the large isolating capacity was to make the gain sufficient for satisfactory operation of a loudspeaker, which is not generally practical with the conventional two-stage resistance-coupled amplifier.

How to Take Care of Phase Shift

However, if the circuit was followed exactly as diagrammed, the result would be exactly as described. The introduction of motorboating would follow if the condenser were placed in the preceding stage (detector to first audio in that circuit), or if a combination three-stage amplifier were used, in which there was a transformer, push-pull or otherwise. Then complications arise from phase shifts. The solution, if large capacity introduces motorboating, is to shift this capacity, since instability in one position will result, and stability in the other, due to the phases of the voltage in respect to the current being 180 degrees apart as between respective elements of successive resistance-coupled tubes. Therefore any who deviate from prescribed circuits should take into account the suggestion for shifting the large capacity.

One man who built the amplifier as described in the February 21st issue reported that results were exactly as stated, and that he was more than gratified. But when he tried the same method on a three-stage amplifier, consisting of two resistance-coupled stages and one transformer coupled cascade, with 245s in push-pull output, he encountered motorboating. He also said that the two-stage amplifier, as diagrammed, and which he followed faithfully, permitted the use of higher values of grid leaks throughout, without instability. So he was puzzled. But he was advised to shift the large capacity, and soon he reported back that again he was gratified.

The values of the grid leaks are important. They seem small, in comparison to more usually recommended values, since they are only 0.5 meg., but if no instability is encountered, larger values of grid leaks may be used. In fact, the rule is to make them as large as practical without running into motorboating, and the small values are given only because there goes with them an assurance of stability.

BF Choke at Input

The input to the power amplifier has a radio frequency choke coil by-passed by suitable capacities, so that RF will be kept out of the AF channel. This, too, aids stability, since if RF gets through, it is unfortunately well amplified in a resistance-coupled chain. In fact, the tuner itself may be thrown into RF oscillation due simply to the RF gain in what should be exclusively an audio amplifier. So, if your tuner has a filtered detector output, nevertheless you may include the filter diagrammed in Fig. 1, as an extra precaution.

The plate resistors are 0.1 meg. This is a suitable value for the 227 tube. It is preferable to use this tube, rather than the screen grid tube, because of the trickiness and instability of the screen grid tube in audio amplifiers. The 0.1 meg. value should not be greatly exceeded, as when the resistance is increased, so is the effective capacity across the signal line, which attentuates the higher audio frequencies. In television work particularly would this be a serious drawback, while even for broadcast reception one wants to hear the violin just as it sounds at the studio, with the natural raspiness of certain high notes, as well as the hissing consonants of speech that make for intelligibility.

Transformer Data

The first and second audio amplifier tubes have heaters in series, because fed by a 5-volt source, marked "6 volts" on the power transformer. The output tube filament is connected in parallel with the 2.5 volt winding, so marked on the transformer, while binding posts may be brought out, or twisted pair, to enable connection of two heater type tubes to the same wind-

LIST OF PARTS

Coils

One power transformer, type K
One B supply choke coil, 30 henries, type K
One 50 mlh radio frequency choke coil

Condensers

Two .00035 mfd. fixed condensers
Two .01 mfd. fixed condensers
Four 8 mfd. electrolytic condensers with mountings
Four 1 mfd. bypass condensers (200 volts DC rating, or higher rating)

Resistors

Three 0.1 meg. Lynch metallized pigtail resistors
Three 0.5 meg. Lynch metallized pigtail resistors
Two 6,000 ohm biasing resistors
One 30-ohm center-tapped resistor
One multi-tap voltage divider (17,100 ohms total)

Other Parts

One 9x11 inch subpanel, with four sockets for tubes, and four extra holes for inverted mountings of electrolytic condensers
One socket wafer for insulated mounting of one electrolytic condenser.
One AC switch
One binding post
One bakelite twin jack assembly, marked "Speaker"
One dozen 6/32 nickel-plated machine screws, and one dozen nuts to match
One roll of hookup wire

Broadcasts and Phonograph

Rofpatkin

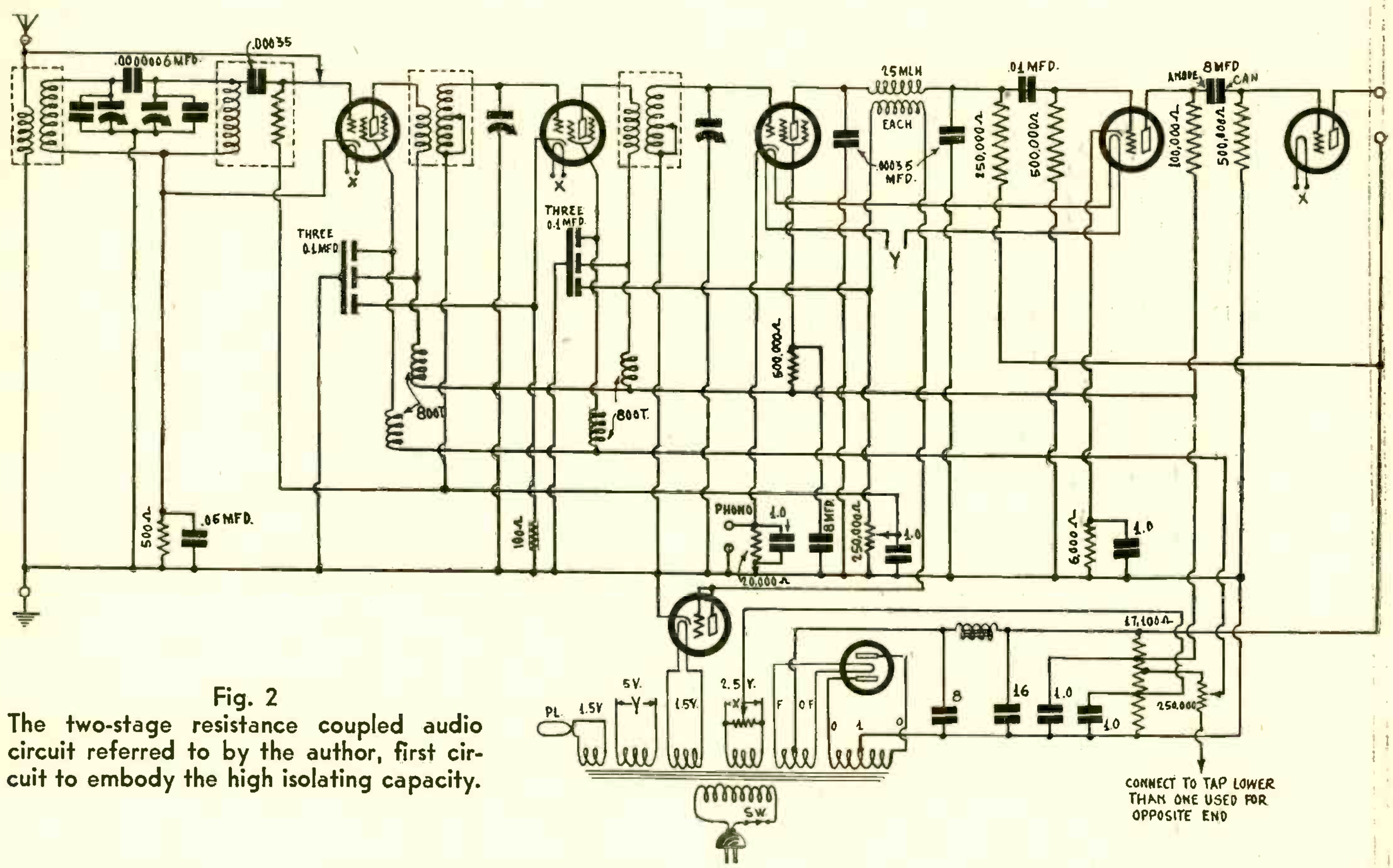

Fig. 2
The two-stage resistance coupled audio circuit referred to by the author, first circuit to embody the high isolating capacity.

ing as supplies the power tube filament. This would put a 50-volt positive bias on the heaters of these two tubes, but the procedure is now well accepted as satisfactory, and no hesitancy need be felt about following this system.

The filament winding for the rectifier is marked F-C-F, the two Fs going to the filament, the C, or center, being used for oibtaining the positive voltage from the 280 rectifier, for connection to one side of the B supply choke and the anode of the 8 mfd. electrolytic next to the rectifier.

The high voltage winding, 1-0-1-, has rectifier tube plates connected to the respective 1s, while center, which is marked 0, goes to grounded B minus. There are two other windings, marked 1 12 volts, but if one heater type tube is connected to each such winding, the resultant voltage will be 2 volts, which is sufficient. So four heater type tubes may be worked, additional to those in the audio amplifier. Of course the 1 12 volt windings may be used for 226 tubes, if preferred, whereupon as many as six such tubes may be served by the two 1 12 volt windings.

The electrolytic condensers are sensitive to polarity. The anode is represented by the binding post in center of one end, and is to be connected to positive. The can is to go to negative. Thus the can may be connected to the metal subpanel, which is B minus and ground, in all instances except that of the isolating condenser, which must be insulated from the chassis. The socket wafer affords such insulation. If a phonograph pick-up input is desired, arrange to cut the pick-up in and out, across the first grid leak (grid of first audio tube to B minus), leaving the leak in position.

The New All-Wave De Lu

By BRUNSTE

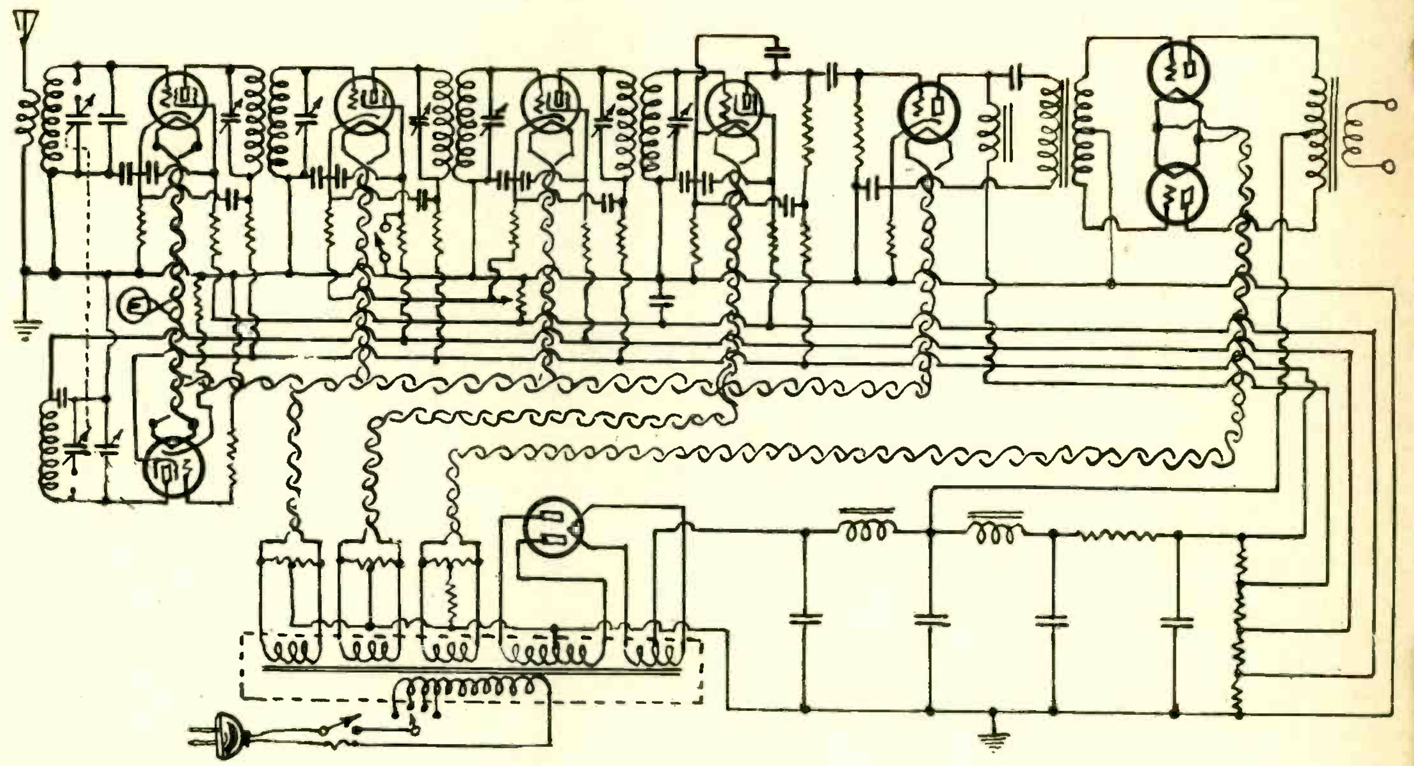

FIG. 1
Circuit diagram of the L-32 Ultradyne, an up-to-date, all-wave super-heterodyne characterized by the use of a plio-dynatron oscillator.

THAT the all-wave superheterodyne should come was inevitable, for it offers so many advantages. It will bring in the broadcast stations as well as or better than any other receiver, and in addition all television, short-wave broadcast, code, and all kinds of signals. Only a superheterodyne seems suitable for such a receiver, for only in the superheterodyne does the main amplification occur at the same radio frequency regardless of the frequency of the signal.

We present the L-32 Ultradyne, a complete receiver of this type making use of the system of modulation invented by the late Robert E. Lacault and made famous by countless successful receivers of the type. The L-32 incorporates all the latest improvements in circuit design that have stood the test of trial and utility. Many of the new kinks put in some receivers to satisfy whims and at which we smile have been left out, a real credit to the designers.

In looking over the circuit diagram of this new receiver one is impressed by the fact that nothing superfluous has been included to clutter up the circuit and to render it less efficient. On further study of the circuit one realizes that nothing has been left out that serves a useful purpose, that no part has been put in just for appearance, that no connection has been made this way or that without a sound reason for it. One cannot say of this receiver that it is "just another superheterodyne," but one must say that it is a thoughtful new design.

Plio-Dynatron Oscillator

One deviation from the usual is the use of a plio-dynatron oscillator. This oscillator employs a screen grid tube and operates on the principle of negative resistance without the usual tickler coil. To bring about the condition for oscillation the screen voltage is made higher than the plate voltage. An oscillator of this type has been found to possess exceptional frequency stability over an extremely wide range of frequencies. The frequency stability is an important feature in an all-wave superheterodyne as it prevents interlocking of the tuned circuits. It also possesses the advantage of simplicity. There is no other oscillator as simple as this..

The intermediate frequency in this circuit is 245 kilocycles. It is placed at 245 rather than at 250 or 240 in order to avoid its being a multiple of ten and thus to avoid heterodyning and image interference. Another reason for using 245 kc. is to avoid interlocking of the tuned circuits at the high frequencies which would occur if the intermediate frequency were low, for there is coupling between the tuned circuits other than that intended. However minute the stray coupling may be it may become annoying when the signal and oscillator frequencies differ by only a small percentage.

Gang Tuning

The oscillator and the radio frequency tuner are tuned with one control. This is quite a feat in an all-wave superheterodyne. It is accomplished by having a trimmer condenser across each of the high frequency circuits. For short-wave reception the trimmers are the tuning controls while for broadcast re-

Forum

Warning on Motorboating

A WORD of advice to brother fans who are following RADIO WORLD'S excellent articles on resistance-coupled audio designs. Any pronounced motorboating encountered, if not promptly removed, will tend to puncture paper filter condensers in plate or speaker filter circuits almost as fast as they are replaced. This is rather expensive and am passing my experience on to any whom it might benefit.

Also, there are a lot of us who are not greatly interested in short-wave operations, so don't crowd out the good standard up-to-date concert band designs.

GEORGE E. SEIBERT,
Box No. 233, Bridgeport, Ohio.

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ception the main condensers are switched in and the trimmers are then only trimmers to be used when necessary or desirable.

Attention is called to the thoroughness of the filtering of the circuits and the manner in which the by-passing has been done. Each stage has its own grid bias resistor. Thus there is no coupling among stages from common bias resistors. All by-passing in any one stage has been made to the cathode of the tube in question. Thus there are three condensers connected to most cathodes, one for the bias resistor, another for the screen voltage, and still another for the plate voltage. And in each screen and plate lead there is a filter resistor below the condenser to complete the isolation of the circuits with respect to the B supply. But the common portions are by-passed, too, and with larger condensers.

Intermediate Tuners

There are six tuners in the intermediate frequency selector and three transformers, both the primary and secondary of each being tuned. The coupling between each primary and secondary has been determined experimentally to combine the highest possible efficiency consistent with selectivity. The tuner is exceedingly sharp yet not so sharp as to cut sidebands. Each tuner acts as a band pass filter.

The shields over the intermediate coils are oversize so that there is a negligible loss in them, which helps both the selectivity and the sensitivity. Yet the shields are effective in eliminating interstage coupling. The tuning coils have comparatively high inductance so that the tuning capacity across each is small. This makes the L/C ratio high, which in turn makes the sensitivity high. It is so high that the noise level is reached long before the maximum sensitivity, except in extremely quiet locations.

The Audio Amplifier

The audio amplifier consists of two stages, one single tube coupled to the detector by means of resistance-capacity and the other 245 push-pull coupled to the first by means of transformer. Saturation of the primary of the push-pull input transformer is prevented by the parallel feed method. That is, a choke coil is used for feeding the plate of the first audio tube and a condenser is put in series with the primary to keep out the direct current. In this respect we note that the primary of the transformer is returned to the cathode and not to ground. This is one of the refinements with which this receiver is replete.

Good fidelity is assured by the grid bias second detector, resistance coupling between the detector and the first audio, push-pull 245 output, parallel feed method of coupling between the first and second audio stages, and bandpass type of tuner in the intermediate amplifier.

Both detectors are screen grid tubes and each is self-biased with a 15,000 ohm resistor. The first detector has 180 volts on the plate and 25 volts on the screen, and the second detector operates under the same conditions except that the late load is a 0.25 megohm resistor.

Image Interference Remedy

Image interference is the weak point in every superheterodyne, and the more the designer of a circuit succeeds in suppressing it the better the receiver will he turn out. There are two methods of attack on the problem. One is to tune the radio frequency signal so sharply that the signals differing by twice the intermediate frequency are so suppressed ahead of the first detector that they cannot even produce a chirp when mixed with the desired station. The second is to increase the intermediate frequency. We have the choice of using many tuners at radio frequency or a high intermediate frequency.

In this receiver, the L-32, the intermediate frequency is 245 kc, as has been stated. Twice that is 490 kc. It would seem that almost any tuner would be sharp enough to segregate two signals differing by 490 kc. The designers of the receiver under discussion found that a single sharp tuner was sufficient, therefor there is only one, but it is selective.

Power Supply

There are three 2.5 volt windings on the power transformer. One of these serves all the cathode type tubes with the exception of the second detector, which has a winding all to itself. The third winding serves the two power tubes. Each of the windings is balanced by a center tapped resistance, the center of which is grounded, except that in the third winding a 790 ohm bias resistor is connected between the tap and ground. This bias resistor is not by-passed because an unby-passed bias resistor in a push-pull stage tends to equalize the signals on these tubes in case they are slightly different to begin with.

The rest of the power supply is typical. The rectifier is a 280 type tube and the filter contains two chokes and the usual by-pass condensers. The plate current of the power tubes flows through only one of the chokes. Taps are brought on the voltage divider at 25, 85, 130, and 180 volts.

Mechanical Features

Considering the fact that the circuit contains nine tubes in all together with necessary tuners, transformers, and condensers, the L-32 is of very small dimensions. The overall size is only 18.5 inches long, 11 inches front to back, and 8 inches high. Notwithstanding this compactness there is no crowding of parts as may be seen from the photographs, to be shown next week. The small physical dimensions of the receiver makes it adaptable to modern consoles and cabinets.

The tuning range of the circuit is from 550 to 20,000 kc, which is enough to cover practically all the radio spectrum used at present. Those stations operating below 550 kc are of little interest and those above 20,000 kc are little used. If considerable activity in the ultra-short waves should develop, it is a simple matter to extend the range of the tuner to take them in.

RADIOGRAMS

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"Business without ballyhoo" will be the keynote of the annual radio trade show at Chicago in June. Revival of radio, as well as other business, already is indicated in the advance applications of manufacturers for exhibit space.

* * *

Midget receivers are still proving the most popular sales attraction in retail stores.

* * *

Many set manufacturers, not yet making superheterodynes, are working on them nevertheless, but the number of licenses to be issued is restricted, and some manufacturers, licensed for TRF only, may be disappointed.

Pointers on the Choice of Tubes for Circuits

WHICH tube should be used in a radio set? What is the difference in results? The 226 tube has four contacts. The filament is heavy, so that the variations in the alternating current do not cause very much flicker and corresponding hum. Still, there is some hum resulting.

The 227 tube, originally mode for detection, does not have the filament directly connected in the circuit. It uses the heat of the filament to warm an additional element, which is really the element from which the electrons are given off.

This heater type tube causes practically no hum, so that in addition ot using it for a detector, it is becoming more and more popular for use in other circuits, such as the radio frequency and audio amplifiers. The screen grid tube is coming into favor for the radio frequency sockets, too, so that presumably, the 227 will be confined to the detector and audio sockets for future use.

A Comprehensive Tester

By Henry

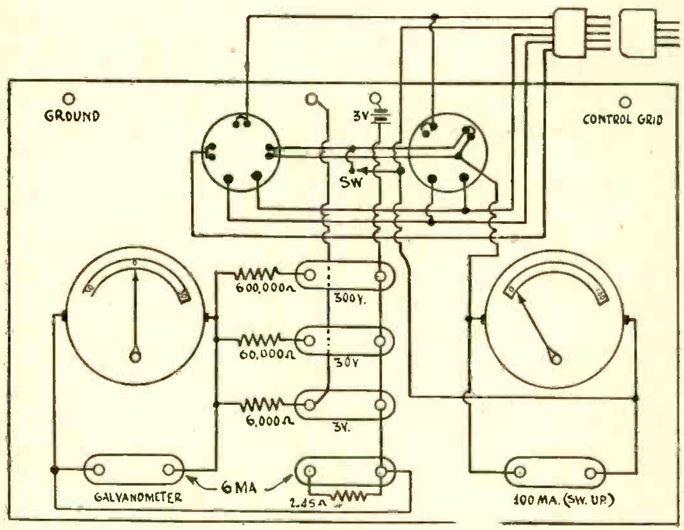


Fig. 1
The circuit of the tester.

LIST OF PARTS

One Weston Model 375 Switchboard DC galvanometer, 0.5 ma. full-scale deflection.
One Weston Model 301 Switchboard O-100 milliammeter.
One 8⅜x5½ inch drilled and engraved bakelite panel.
One walnut finish wooden cabinet to fit.
Three Lynch wire wound precision multiplier resistors; 6,000 ohms, 60,000 ohms and 600,000 ohms.
One 2.45 ohm shunt resistor.
Four binding posts.
Two 1.5 volt dry cells.
Two clips for holding dry cells inside cabinet.
Six bakelite twin jack assemblies.
One Benjamin switch.
Two sockets (one UX, one UY).
Two Best socket adapters with removable brads (one UX, one UY).
One 5-lead cable with UY plug and UX adapter.
One grid clip and one grid cap.
One roll of hookup wire.
Two test leads, pin plugs at both ends.

Value of Outfit Enhanced by Table

TABLE OF SCALE DIVISIONS, CURRENT EQUIVALENTS, AND RESISTANCE VALUES, FOR THE 0-.5 MILLIAMMETER. THE 3 VOLT BATTERY AND 6,000 OHMS ARE IN SERIES WITH METER FOR RESISTANCE WORK.

Meter Reads	*Milli-amperes*	*Ohms*
.25	.00416	714,000
.5	.00833	354,000
1	.01666	174,000
1.7	.0283	100,000
2	.0332	84,000
3	.05	54,000
3.2	.0536	50,000
3.0	.0635 .0652	40,000
4	.067	39,000
5	.083	30,000
6	.1	24,000
6.9	.115	20,000
7	.1167	19,700
8	.133	16,500
9	.15	14,000
10	.1666	12,000
11	.1833	10,370
11.25	.1875	10,000
12	.2	9,000
13	.217	7,850
14	.234	6,860
15	.25	6,000
16	.267	5,250
16.3	.272	5,000
17	.284	4,590
17.5	.282	4,500
18	.3	4,000
19	.317	3,475
19.1	.318	3,500
20	.334	3,000
21	.35	2,570
21.15	.353	2,500
22	.367	2,180
22.5	.375	2,000
23	.383	1,827
24	.4	1,500
25	.417	1,200
25.7	.428	1,000
26	.434	924
27	.45	667
27.8	.461	500
28	.467	429
29	.483	207
29.5	.492	100
30	.5	0

The values given in the accompanying table apply to any 0-.5 milliammeter, when the equivalent current alone is to be determined in respect to the needle on 90-30 scale. This is important, since the scale numbers give relative values, while the table affords current calibration. The resistance values apply only when 3 volts and a 6,000 ohm resistor are connected in series with the meter.

It can be seen that the unit scale divisions give many resistance values in round numbers, which is helpful. These round numbers are the actual precise values. However, there are commercial values of resistance that do not come out in round numbers, in respect to unit devisions of that scale. Therefore some decimal scale values are included, and attaining the decimal has to be done by estimating with the eye when reading the meter.

It will be seen that 100 ohms is the lowest resistance value that can be easily read, this at a setting of 29.5 on the scale, while the highest easily read value is 354,000 ohms.

The value 207 ohms for 29 on the scale may be used in testing for 200 ohm resistance values, since commercial resistors likely will not be 3.5 per cent accurate. No. 28 on the scale may be used for 400 ohms. After 500 ohms, either by natural result in round numbers for unit readings, or by interpolated decimal readings of the scale, the common values provided for are 1,000, 1,500, 2,000, 2,500, 3,000, 3,500, 4,000, 4,500, 5,000, 6,000, 10,000, 20,000, 30,000, 40,000 50,000 and 100,000 ohms.

Although the highest resistance value is given as 714,000 ohms, this requires a sharp eye to read correctly.

A GREAT part of the enjoyment of radio work lies in the use of accurate meters, for measuring voltages and currents particularly, while as an easy adjunct it is desirable also to measure resistance values. Besides, the testing equipment, while consisting of independent meters, should be of the plug-in type, so that measurements may be made in a receiver, which is a great aid to service men.

All these assets can be enjoyed quite readily by the use of standard testing equipment made by various companies, but not all who have the desire to possess this type of accurate equipment have the means with which to satisfy the desire. Therefore a device that one builds himself, where the cost is relatively low, will serve the purpose nicely, if it will provide the required measurements, and also will afford the accuracy.

Uses Two Meters

In general, the accuracy depends on two things: first on the meters themselves, and second on the series resistors used for voltage multipliers, or shunt resistors used for current multipliers. When resistance is to be measured, the voltage of the dry cell or cells under load must be the voltage that was taken into consideration when selecting the limiting resistor used for ohmmeter work.

Two meters are used in the Model T-1 Tester. One is a galvanometer that at full-scale deflection, on either side, represents a current flow of 0.5 milliampere. The scale has 30 divisions each side of zero. No matter what multipliers are used, when the instrument is thus constituted as a voltmeter it has a resistance of 2,000 ohms per volt. The definition of the ohms-per-volt rating of a voltmeter is that, at full-scale deflection, the rating in ohms per volt is the meter and multiplier resistances divided by the voltage. The meter resistance usually is negligible in instruments that are sensitive. This, if the voltage at full-scale deflection is 300 volts, and the meter-and-multiplier resistance 600,000 ohms, the ohms-per-volt rating is 2,000. To obtain the ohms-per-volt at full deflection, divide the number 1 by the current in amperes. A better way to rate the meter would be to state its full-scale deflection current directly, as ohms-per-volt, at less than maximum reading, does not mean number of ohms for each volt measured.

Meters Identified

With any good meter stating relative values the full-scale deflection current can be obtained from the manufacturer's catalogue, or by correspondence with the manufacturer, or it may be measured, if you have another sensitive current meter. Suppose you have a 0-1 milliammeter. Then you connect this in series with the meter to be measured and note what the reading is on one when the other's scale is fully deflected, since the same current flows through both.

In this way the full-scale current of the galvanometer was determined to be 0.5 ma, the measuring meter being a 0-1 milliammeter. The measurement was made because the Weston instrument used, a DC galvanometer, was being checked to determine if it was like another DC galvanometer of the same manufacture, which had .667 milliampere full-scale deflection, or about 22 microamperes per division, but it was found the instrument at hand drew only 0.5 ma at maximum, or 16.67 microamperes per division. The same meter can be duplicated, since it is a 0-1 milliameter with the zero pointer setting at center, instead of at one end.

What Can Be Measured

The other meter is a Weston 0-100 milliammeter. It is included principally to enable simultaneous reading of plate current with

at 2,000 Ohms Per Volt

B. Herman

other voltage or current readings with the other meter, useful in running curves on tubes, or checking up receivers.

The main measurements to be made with the device as constituted by the two meters and adjuncts are as follows:

Current

0-0.5 DC ma, the current values at each particular division and at some decimal divisions being given on an accompanying table, other values to be estimated from the meter reading, since the current is directly proportional to the scale. Also, without any particular regard to the amount of current, the instrument is used as a galvanometer to determine the zero current condition required in constructing or using bridge circuits for DC resistance measurements, in other words, as a balance indicator.

0-6 DC ma, by incorporation of a shunt resistor of 2.45 ohms. The connection is made between jacks of two adjoining receptacles, instead of across one receptable, to avoid a switch. This range is necessary, because the 0-100 meter has 5 ma per scale division, and the determination of smaller current values, other than 2.5 ma, would include too much guesswork. The 0-6 ma scale is valuable indeed in measuring plate current change when the grid voltage on a tube is varied in minute values, which voltage measurement is also furnished by the Model T-1.

0-100 DC ma, the range of the other meter. This instrument is in series with the plate circuit, between the tube socket of the receiver being tested, and the tube that is taken from the receiver socket and placed in the proper tester socket. But, by closing the only switch used (pulling up the knob, unlike the action of most other switches) the 0-100 ma may be used independently, for external measurements, but not when the tester plug is in a receiver.

Resistance

100-714,000 ohm DC resistance meter, constituted of a 6,000 ohm series resistor and two 1.5 volt flashlight cells. The resistance values for the thirty unit scale divisions are given in an accompanying table, as well as for some decimal scale divisions.

Voltage

0-3 DC volts, a scale for close reading of low voltages, especially bias, useful in testing tubes, in conjunction with the 0-6 ma scale, although in this particular regard (reading the small bias voltages and small plate currents) the same meter is used, hence only one reading is obtainable at a time. The same 6,000 ohm resistor is used as for the resistance measurement.

0-30 DC volts, for measuring larger bias voltages, and other voltages.

0-300 DC volts, for measuring plate voltages particularly.

Seven Distinct Uses

Therefore from two meters, seven distinct uses are obtained, all the voltages being read on a 2,000-ohms-per-volt voltmeter.

The meters and their uses are independent of the test circuit, except for the 0-100 milliammeter, which, by the switching arrangement, is made available for independent use. The reason for constituting the device this way is that many tests are made independently of radio receiver trouble-shooting and testing, and therefore the requirement of independent meters is at least as great as that for receiver testing.

However, two special adapters, one for the five-prong socket, another for the four-prong socket, enable the connection of a plugged cable for cutting in the current meters for 0-0.5 ma and 0-6 ma cathode, control grid, screen grid or plate circuit (since current indicators must be in series with the circuit), while the voltmeter scales may be used, without regard to polarity, by touching test leads to the desired points on the adapters between which the voltages are to be measured.

Reason for Ground Post

In this connection it is well to stress the desirability of a ground connection. The bias voltage on heater type tubes, for instance, is usually the voltage between cathode and ground, and it can be measured accurately by the voltmeters. However, it is not possible to pick up ground infallibly, since the only possible access thereto would be the grid of general purpose tubes, or the control grid of screen grid tubes, as these go eventually to ground. In radio frequency circuits this would be all right, but in audio circuits a high resistance load is in the grid circuit, and in resistance coupling it constitutes a very high DC resistances through which the meter current would have to flow. Therefore a binding post has been provided for connection by a wire to the ground post of the receiver for accurate measurement of bias voltages.

Symmetrically placed in respect to this ground binding post is another binding post, this one for the control grid when screen grid tubes are to be measured. A flexible wire lead with grid clip at one end is installed in between the two sockets, and knotted, so that it can not be pulled out either way. Then this lead is carried on to the control grid post on the tester.

When a screen grid tube is removed from a receiver and placed in the tester the control grid connection is not made automatically, but a grid clip, attached to a wire, remains "open" in the set.

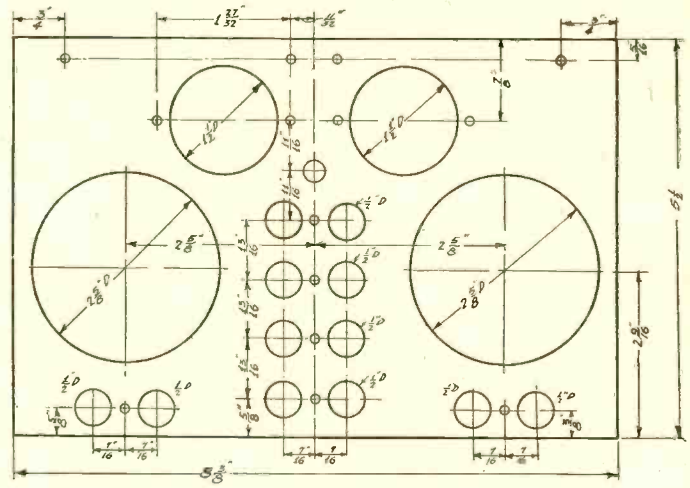


Fig. 2
Drilling dimensions for the panel.

Therefore a wire lead, with cap at one end corresponding to the cap of a screen grid tube, is connected with bared terminal to the control grid binding post of the tester, while the grid clip in the set is placed on the cap of the wire. The object of the post is simply to protect the tube in case of accidental strain on the lead running to the control grid in the set. Sometimes a man will forget to remove all leads, and it seems to be a popular form of forgetfulness to try to walk away with the tester when the control grid clip is on the tube in the tester and the other end of the lead is in the set. The result usually is that the tube is ruined, in fact, the cap is totally dislocated and even the envelope punctured.

The independence of the meters from the testing circuit (except in the modified instance of the 0-100 milliammeter) requires that connections be made to the circuit. Test leads are used for this purpose. Since twin assemblies of the type familiar for speaker and phonograph connections are used, and as the jacks therein require plugs, the familiar speaker tip plugs are soldered to one end of the pair of test leads, while at the other end are connected tip plugs, but with shorter shanks, since the receptacles into which they are to fit (eyelets in the special socket adapters) will not take the longer shanks.

The Special Adapters

As for these special adapters, they simply provide access to the voltages and currents in the tube and circuit under test. For each element there are two eyelets side by side. One connects to the tube prong. The other goes on to the cable at the other end of which is UY. plug. A four-prong plug adapter enables use of the same cable plug, in insertion in receiver's tube socket. A U-shaped brad establishes the continuity, and as this brad is removable, access to the current is available for such measurements, and, without removal, access to the voltages as well.

So the procedure is to place the special adapter (known as the Best, from the name of the manufacturer) in the tester's socket, and put the tube in the spring receptacles that jut upward from the adapter. Moreover, these spring receptacles may be used for voltage measurements instead of the brads, if desired.

One of the special adapters has four prongs, the other five, so all types of tubes may be tested with them. The tester itself has two sockets, for the same object of taking care of all types of tubes.

Screen Grid Tube Terminals

Only the screen grid tube causes confusion among experimenters. There are two types, the battery type (222 and 232) and the AC type (224 and G-51 variable mu tube). The battery models go into the four-prong spring socket. The filament is familiar. The screen grid contact made to the tube prong is what is normally the plain grid of a general purpose or power tube. The cap is the control grid and is one of the two points of input to the tube, the other usually being ground. The AC types follow the same lines as to screen grid and control grid, but there is an extra element, the cathode, or electron-emitter, hence a five-prong base is used.

The tester will measure grid current, although hardly in absolute values, since such current is very small. In certain detector circuits and in amplifier circuits that are overloaded, grid current will flow, so that registration is noticeable on the galvanometer scale. Since the galvanometer measures 16.7 microamperes per scale division, it is quite easy to determine grid current flow if it is only 4 microamperes, although, as stated, the determination of absolute value is not practical.

A Highly Accurate, Wide-

By Einar

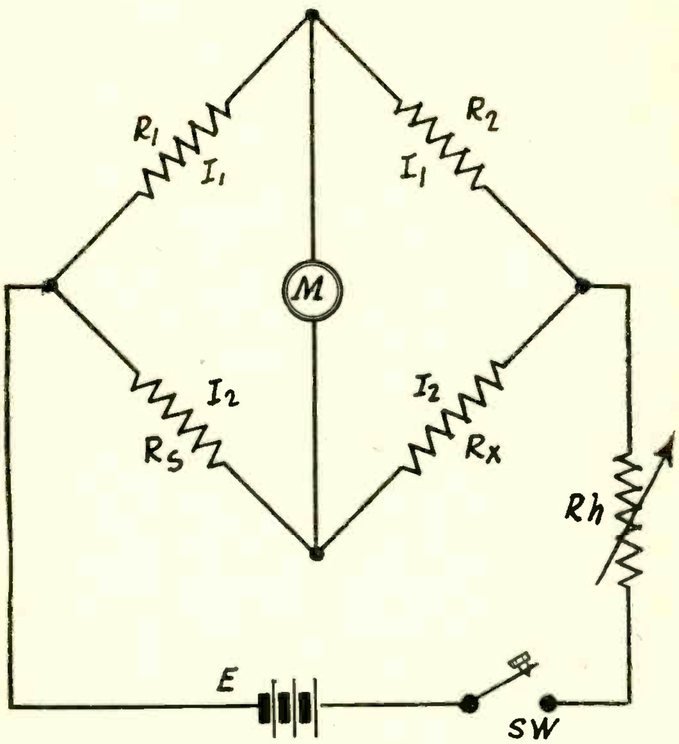


FIG. 1
The circuit of a Wheatstone bridge for measuring unknown resistances.

WHEN resistances are to be measured accurately an instrument known as a bridge is employed, and for quick and routine measurements the Wheatstone bridge is used, which is a very simple device both in principle and in use. The principle of this instrument is best explained by means of a diagram, such as Fig. 1. Four resistances, R1, R2, Rs and Rx are connected in series in the form of a square or a parallelogram. A battery or other source of electromotive force is connected in series with one diagonal and a balance indicator, usually a sensitive galvanometer, is connected in the other diagonal. That is to say, the battery connects two opposite corners and the balance indicator the other two.

It is clear that in general a current will flow through the meter M in Fig. 1. The only time when it will not flow, the battery being connected, is when the circuit is balanced. Off balance the current through the meter will flow in either direction, depending on the values of the resistances. Because the current may flow in either direction when the bridge is unbalanced, the meter should be of the type which reads in either direction, that is, one with the zero in the center. Nearly all galvanometers and many sensitive milliammeters are of this type.

Condition for Balance

The relationship that must obtain among the four resistances when the bridge is balanced can be obtained with little difficulty. When no current flows through the meter the same current flows through R1 as through R2. Likewise, the same current flows through Rs and through Rx. Let these currents be indicated by I1 and I2.

Also, when no current flows through the meter the potential difference across it must be zero, for if there is no current there is no voltage drop. Hence the potential at the junction of R1 and R2 is the same as the potential at the junction of Rs and Rx. Hence the voltage drop in R1 must be equal to the voltage drop in Rs and the voltage drop in R2 must be equal to that in Rx. Therefore by Ohm's law we have the two equations $R1\,I1 = Rs\,I2$ and $R2\,I1 = Rx\,I2$. Divide the second by the first, member for member. The left hand side gives R2/R1, I1 canceling out, and the right hand side gives Rx/Rs, I2 canceling out. Since we divided one equality by another equality the quotients must also be equal and we have $Rx/Rs = R2/R1$. This is the relationship that must obtain among the four resistances in order that no current should flow through the balance indicator.

Construction of Bridge

Multiply the resistance ratio equation by Rs and obtain $Rx = Rs\,(R2/R1)$, which gives the value of the unknown resistance Rx in terms of the standard and known resistance Rs and the ratio of two resistances R2 and R1. Thus if we have a variable standard resistance and a means for varying the ratio of R2 and R1, we have a means of measuring a wide range of resistance in terms of our standard.

It is customary to construct the bridge with one fixed resistance, which may be either R1 or R2, one resistance variable in large steps, which also may be R2 or R1, and one resistance variable in small steps from one ohm to 11,110 ohms. This must be Rs, the standard. Sometimes the standard is variable from one ohm to 1,110 ohms. In the first case the standard is a four dial decade resistance and in the second it is a three dial decade resistance.

It is customary to arrange the resistance variable in steps so that the ratio R2/R1 is multiples or submultiples of 10, so that when Rs has been varied until balanced has been obtained, it is only necessary to multiply or divide the reading on the dials by multiples of ten.

Suppose we let R2 be the fixed resistance and let its value be 1,000 ohms. Then R1 will have to be the one that is variable in steps of multiples of ten. Let the values of R1 be 1, 10, 100, 1,000, 10,000, 100,000, and 1,000,000 ohms. These will make the value of R2/R1 1,000, 100, 10, 1, 0.1, 0.01, and 0.001, respectively.

Let us assume that our standard resistance is a three dial decade having 10 unit resistors, 10 tens and 10 hundreds.

Suppose now we wish to measure the resistance of an

Right or Wrong?

Questions

(1)—When the bias for a tube is obtained from a resistance serving that tube alone, the bias remains constant regardless of the plate current in the tube.

(2)—When the bias for a tube is obtained from a resistance in the cathode lead the signal can swing the grid so much negative that the plate current is cut off much more easily than if the bias is obtained from a battery.

(3)—A grid bias resistor reduces the amplification of a tube.

(4)—If the voltage across the primary of a power transformer supplying a set is measured and also the current flowing into the primary, the power taken by that set is obtained by multiplying the voltage by the current.

(5)—The best way to ruin a dry cell battery is to test it often with an ammeter.

Answers

(1)—Wrong. The bias is directly proportional to the plate current so it cannot remain constant. When the plate current is stopped entirely the bias is zero.

(2)—Wrong. As the signal swings the grid negative the plate current is reduced. But this also reduces the grid voltage or bias so that the plate current tends to remain where it was. Thus it takes a much stronger signal to produce a given change in the plate current when the bias is obtained from a bias resistor than from a battery.

(3)—Right. The answers to (1) and (2) indicate why this is so. The plate current through the bias resistor always changes the bias in the direction opposite to the direction in which the signal changes it. If there is no by-pass condenser across the bias resistor this reduction in the amplification may be very great.

(4)—Wrong. The power thus obtained is not the power used by the set because part of it will be returned to the line. It simply surges back and forth. Only that portion of the current which is in phase with the voltage is effective in determining the amount of power taken from the line.

(5)—Right. While taking a test with an ammeter is the best way of finding the condition of the battery, the current is so heavy (30 amperes) that frequent tests rapidly exhaust the battery. A much better way of testing a dry cell or dry cell battery is to measure its voltage when no current is taken, except that required by the voltmeter, and again when it is delivering the maximum rated current. For a No. 6 dry cell the rated current is one-quarter ampere. If the voltage drops much below 1.5 volts per cell the battery is not in good condition.

The simplest way of testing the condition of a dry cell or dry cell battery is to measure its voltage with a voltmeter that draws an appreciable current, say one that has a sensitivity of 50 ohms per volt and therefore draws 20 milliamperes at full scale deflection. If the internal resistance of the battery is high because of exhaustion the voltage reading will be low. If a 1,000 ohms per volt instrument is also available a reading with this should show almost full voltage. If this also reads low, the battery is dead.

Range Resistance Bridge

Andrews

unknown resistor. We put it in the arm for Rx in the bridge, set the ratio at unity, that is, we use the 1,000 ohm resistance for R1. Then we adjust the rheostat in series with the battery to a high value so that no damage will occur to the meter when we press the key switch. There will be a certain deflection on the meter. Now set the unit and the ten dials on the lowest stop and by means of the hundreds dial try to find a balance. If the unknown resistance lies in the range covered by this dial, that is, if the resistance is less than 1,000 ohms, there will be one point where the deflection on the meter will reverse. For example, at 700 ohms it may be in one direction and at 800 in the opposite direction.

Set the hundred dial at 700 and next go to the tens dial. Move the pointer a step at the time and note the deflection when the key is depressed. Again a point will be found where the deflection will reverse. If the deflection is too small to be observed, reduce the rheostat by an appropriate amount. Suppose that we find the balance point to lie between 10 and 20. Then leave the tens dial at 10 and go to the units dial and repeat the process. A point will be found on this also where the current in the meter reverses. Let us assume that it is between 8 and 9. In order to see the deflection in either direction, it may be necessary to reduce the rheostat still further. We now know that our unknown resistance lies between 718 and 719 ohms.

We may wish to know the resistance a little more accurately. To get a more accurate estimate we have to interpolate between the 8 and the 9 on the units dial. We do this by observing the amount of deflection in each direction. Suppose, for example, that when the dial is set at 8, the needle comes to rest at 20 on the left and when the dial is set at 9 the needle comes to rest at 5 on the right. Then one ohm changes the deflection by 25 units on the scale of the meter. Obviously, the balance point is nearer the 9 than the 8, judging by the deflections. Hence the fraction of an ohm that must be added to the 8 is 20/25, or 0.8. Therefore our unknown resistance is 718.8 ohms.

The process for measuring higher or lower resistances is exactly the same, except that the ratio would be different. Suppose, for example, that we had set R1 on 10,000 ohms. The ratio then would have been 0.1, and our unknown resistance would have been 71.88 ohms. And if we had set R1 on 100, our ratio would have been 10 and the unknown resistance 7,188 ohms. If we had used the largest value of R1, the unknown would have been 0.7188 ohms and if we had used the smallest value of R1 it would have been 718,800 ohms.

Range of Bridge

Since the decade resistance contains ten units, ten tens, and ten hundreds, the highest reading is 1,110 ohms and the lowest is one ohm. Since the highest value of R2/R1 is 1,000, the highest resistance that can be measured with this bridge is 1,110,000 ohms, and since the smallest value of R2/R1 is 0.001, the smallest resistance that can be measured with the bridge is 0.001 ohm.

The measurement of the extreme values will not be as accurate as measurements in the middle of the range, because it is more difficult to find the exact balance point. Any measurement cannot be any more accurate than the accuracy of the three resistances in terms of which the unknown is measured. For this reason only accurate resistors should be used in constructing the bridge. Moreover, if the decade resistance and the ratio resistance are varied by a switch, the leads to the taps and the contacts on the switches should have negligible resistance.

We started out by setting the ratio resistance on 1,000 and later proceeded to use the other taps. The question may arise as to the method of selecting the proper ratio resistance in case a balance cannot be found on the first, or 1,000 ohms, ratio resistance. The answer to this is simply that if a balance cannot be found on one ratio resistance, the next to it must be tried. When the unbalance is greater after the change, as judged by the deflection, the ratio resistance on the other side must be tried. That is, if balance cannot be found on the 1,000 ohm ratio resistance, try the 10,000. If this makes the balance worse, try the 100. After the proper direction has been established there is no longer any doubt as to which way to go if a balance cannot be found either at 100 or 10,000.

The use of the rheostat must not be forgotten, for on it depends the safety of the indicator meter. Always use as much resistance as practical. Decrease the rheostat resistance only when it is necessary to get a greater deflection. It should be remembered that the absolute value of a deflection is of no importance. It is only the direction of the deflection when the key is pressed that counts. There is one exception, and that is when interpolation is used to estimate the reading more accurately, and even in this case the absolute values does not matter. The rheostat might well be adjusted until the greater of the two deflections is as large as the meter will permit. The other will then be in the proper proportion.

Use of Shunts

If the indicator meter is provided with many shunts, they may be used in place of the rheostat to protect the meter. This is done in most cases. But the rheostat is convenient in case a zero-center milliameter is used for indicator.

A head set may be used as indicator in the absence of a zero-center instrument, but in this case a source of AC has to be used in place of the battery, or else a switch in series with the headset. If there is current in the bridge circuit there will be a click in the headset when the key is closed and opened. The headset has limitations in that it does not permit interpolation for more accurate balance.

A vacuum tube amplifier could also be used for indicator when high sensitivity is required. But this too is subject to the limitation that it does not permit interpolation.

Wirewound resistors in units, tens, hundreds, thousands, ten thousands, hundred thousands, and millions of ohms are available at reasonable prices and they are held to an accuracy of plus or minus one per cent. Resistors accurate to 0.1 of one per cent can also be had but at much higher cost.

Tube Questions

Screen Grid Tube in Resistance Coupling

WILL a 224 screen grid tube in a resistance coupled amplifier give enough output voltage to load up a 245 power tube, and if the detector is a 227 operating on the grid bias principle and coupled to the 224 with a resistance coupler, will the audio amplification be sufficient? How should the voltages on the 224 be adjusted to insure best results?—T.C.F.

The 224 will give plenty if it is adjusted correctly and there will be enough amplification at audio frequency. Whether there will be enough output to load up the 245 depends on the sensitivity of the radio frequency amplifier. For the plate resistance following the screen grid tube use 250,000 ohms and make the applied plate voltage 300 volts. That is, make it the same as that applied to the power grid and plate combined. Make the grid leak ahead of the power tube 2 megohms and the stopping condenser .02 mfd. The screen grid voltage may be 75 volts provided that it is applied through a 100,000-ohm resistor. The proper grid bias is 1.5 volts, or a little higher. Since the bias resistor must be very high, due to the low current, the bias may be obtained from a 224 radio frequency amplifier, using a 300-ohm bias resistor for this tube. Connect the cathodes of these tubes together and also the two grid returns.

* * *

When to Use Power Detection

WOULD it be advantageous to use a power detector when the audio frequency amplifier contains three stages, the last of which contains two 250 tubes in push-pull?—B. W. C.

No, the only reason power detection is used is to permit the elimination of all but the last tube in the audio amplifier, or in some instances all but the last two stages. There is no sense using power detection when there is so much amplification in the audio frequency amplifier. Power detection does not increase the sensitivity but rather reduces it.

* * *

Connection of Pickup Unit

IS THERE any objection to connecting the pickup unit across the grid leak or in place of the grid leak of the detector? When this is done does the detector tube become an amplifier?—W. R. W.

Connecting pickup unit in this manner makes the detector tube an amplifier with zero bias if the tube is a 227 or 224 and a positive bias when the tube is a 201A. The circuit will work, especially if the grid return is made to the cathode so that the bias is not positive. When the pick-up unit is connected this way it is necessary to kill the radio frequency tuner while the phonograph pickup unit is in use for otherwise the radio signals will come through at the same time as the phonograph music. When radio signals are being received the pickup unit should be disconnected entirely.

Two-Volt Tubes on 110 v. DC

By Herbert E. Hayden

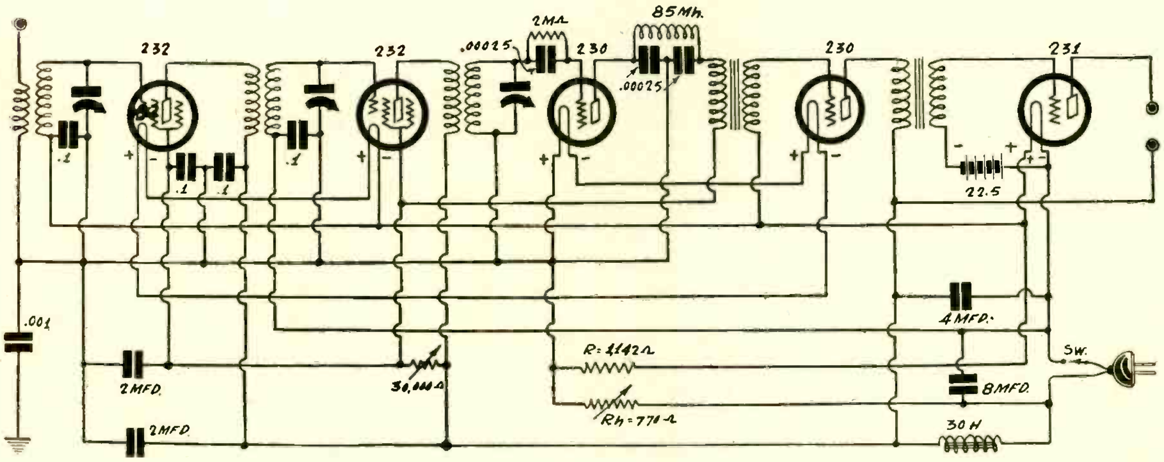


Fig. 1
Circuit diagram of a five-tube receiver with 2-volt tubes served from a 110-volt DC line.

THERE are several populous districts in the United States where the electric power supply is 110 volt direct current. Residents of these distícts cannot use the modern AC sets without a machine for converting the direct current to alternating, and this machine often costs more than the radio receiver itself. Few there are who care to expend the extra money and most people living in these districts either use battery sets or receivers operating directly from the 110 volt DC line.

But in either case the cost of running the receiver is so high that it would almost pay to install the converting machine mentioned for it would soon pay for itself. Suppose, for example, that the set contains a number of 224 or 227 tubes with their heaters connected in series. These tubes require a heater current of 1.75 amperes, and therefore the total wattage is 192.5 watts for the heaters alone. Adding the wattage of the plates puts the total well over 200 watts. Assuming that the set is operated five hours a day, the total energy is one kilowatt-hour a day. With power costing 7.5 cents per kilowatt-hour the cost of operating the set is just 7.5 cents a day, which adds $2.25 to the monthly power bill. It would cost less than half that for an equivalent alternating current set, and the electric set would give much better results.

Reducing the Cost

If we use battery type tubes in the receiver and connect their filaments in series we can reduce the cost of operation considerably, but then we run into complications for not all the tubes of this type that should be employed require the same filament current, and the power taken from the line depends on the tube requiring the most current.

The most suitable tubes for use in such receivers are the new two-volt tubes, because when these are used the current taken from the line will be small and most of the voltage is available for the plates and the screens. Two of the two-volt tubes require 60 milliamperes for the filaments and one, the power tube, requires 130 milliamperes. Hence the current is determined by the power tube if one of them is used in the circuit. A set with these tubes will only require 14.3 watts for the filaments, which is a great saving over 192.5 watts.

If a great deal of volume is not required, but sufficient for entertainment in a home, a receiver built with two 232 screen grid tubes, two 230 tubes, and one 231 power tube is satisfactory, and this can be powered entirely from the 110 volt line, with the exception of a grid bias battery.

Connecting Filaments in Series

The filaments of the tubes should be connected so that the plate voltage is as high as possible on all the tubes requiring a high voltage and also so that the grid bias is provided for as many tubes as possible. The method of connecting the filaments is best illustrated with an example, such as the circuit in Fig. 1.

In this five-tube receiver the power tube is placed at the extreme negative end of the filament series for this allows the highest plate voltage on this tube. If the line voltage is 110 volts the voltage applied to the plate of this tube is also 110 volts. The other tubes requiring a high plate voltage are the two screen grid tubes, and the second of these should have the higher voltage if there must be a difference. Hence the filament of the power tube is run to that of the second screen grid tube, for which the wire runs to the filament of the first screen grid tube. Now there are only two tubes left, and of these the detector requires the lower voltage. Therefore the filament wire is run from the first screen grid tube to the 230 audio frequency amplifier tube and thence to the detector filament. The positive end of the filament of the detector connects with a filament ballast resistance in the positive lead of the power line.

Decrease in Plate Voltage

The decrease in the plate voltage as we go up the series is only two volts per tube. The power tube gets 110 volts, the second 232, 108 volts, the first 232, 106 volts, and the first audio 104 volts. This is on the assumption that the line voltage is just 110 volts and that there is no appreciable drop in the filter choke. The voltage on the screens of the 232 tubes and on the plate of the detector is variable by means of a 30,000 ohm resistance.

The grid bias for most of the tubes is obtained by returning the grids to appropriate points on the filament series. Thus the first grid is returned to the negative end of the filament of the second tube, which gives the first grid a bias of two volts, the drop in the second tube filament. The grid of the second tube is returned to the negative end of the power tube filament, which also assures a bias of two volts for the second tube. The reason is that the power tube is the only one below the second tube in the filament series.

The detector grid is returned to the positive end of its own filament, which is correct for the type of detection indicated. The first audio tube has a low mu and requires a higher bias than the screen grid tube. The grid is returned so that the bias is four volts. This is not quite enough in view of the fact that the plate voltage is 104 volts instead of 90 volts, but it will work. If it is desired to give this grid 6 volts it may be done by returning the grid to the negative end of the filament of the power tube.

Since the power tube is located lowest in the series it is not possible to provide a bias for this tube by the drop method without sacrificing too much voltage that should be used on the plate. Hence the bias for this tube is provided by means of a small 22.5 volt battery. This voltage is too high in view of the fact that the plate voltage is 110 instead of 135 volts. But it is not necessary to use all the voltage in the battery. The proper voltage is about 18.5 volts. The grid battery used should be such that it can be tapped at every cell.

The power tube takes 130 milliamperes and the rest only 60 milliamperes. Hence it is necessary to provide a path for the extra 70 milliamperes. This we do by connecting a resistance R of 114.2 ohms in shunt with the tubes requiring only 60 milliamperes. This resistance is connected from the positive leg of the power tube filament to the positive leg of the detector filament. Seventy milliamperes flow through this 114.2 ohm shunt and 60 through the tubes and the two combine to make the total current through the power tube 130 milliamperes.

The ballast resistance Rh is determined on the basis that the current through it is 130 milliamperes and that the voltage drop must be equal to the difference between the line voltage and the drop in the filaments. Since the drop is 10 volts for five tubes and the line voltage is 110 volts, the drop in Rh must be 100 volts. Thus the resistance should be 770 ohms. Since the line voltage may vary considerably it is best to provide a resistance which can be varied between 500 and 1.000 ohms. The power rating of this resistance should be 13 watts or more.

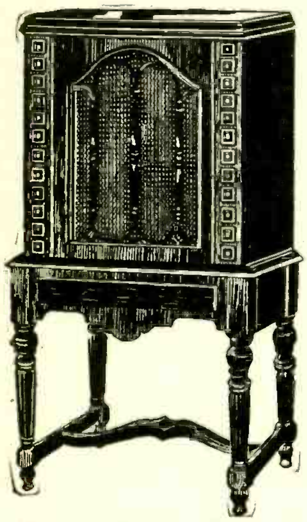
Object of Circuit

The object of this circuit is not to give detailed description of a receiver but to show the order in which the filaments should be connected, how the plate supply should be arranged, and how the grid bias is obtained. The circuit is complete, however, so that a successful receiver may be built around it. All essential values are given with the exception of the tuning coils and tuning condensers.

Diamond Tuner with Drum

Hammarlund Dial Permits Satisfying Diverse Installation Requirements

[In last week's issue, dated March 7th, five Diamond Midget circuits were described. These were an AC tuner without B supply, an AC tuner with B supply, a complete AC receiver, a battery-operated tuner and a battery-operated receiver. The battery models used the 2-volt tubes. The radio frequency amplifier consists of a twice-tuned input, with two stages of screen grid RF and untuned coupling to the detector to build up the amplification at the lower radio frequencies. The AC tuner with B supply was shown as using a flat type dial, while this week the same circuit is shown with a drum dial, heaters being in series.—Editor.]



This cabinet formerly housed only a speaker. The Diamond tuner was installed therein with power amplifier and Farrand inductor dynamic, by an ingenious method described in the text.

FOR some installations a disc type dial will not suffice, therefore a drum dial must be used. The reason is that some persons prefer to house the tuner and other equipment in a special cabinet, one that has furniture effects that interfere with centered location of the dial knob, but do permit the location of an escutcheon through which the dial scale is read. Fig. 1 is an example.

The tuner may be built to accommodate such needs, as shown in the chassis photograph, while the circuit is the same as that published for the Diamond HB Midget. The Hammarlund drum dial model permits the location of the actuating knob at a distance from the scale equal to the length of the tuning condenser plus shaft extensions.

Distance Measured

The question may arise, just how far back from the front elevation should the tuning condenser be mounted? The measurement is taken from the dial drive, from the hub center to the front bracket that goes on the panel.

Of course, for all uses where the drive is separated from the scale by the condenser length, the condenser must have shaft protruding at both ends. The Scovill three-gang .0005 mfd. condenser has this advantage.

How Installation Was Made

The installation in which this circuit was used, as illustrated, called for the location of the extra-long drive shaft on the right-hand side, and made it imperative that the scale should come exactly in the center of the cabinet front. This left little leeway, but it so happened that the two requirements were met without any trouble. The parts just happened to fit that way.

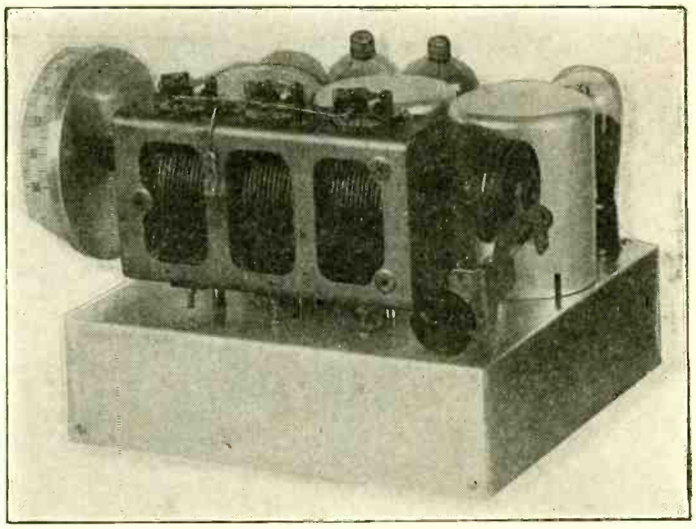
The cabinet used, a beautiful Sonora mahogany model formerly housing a speaker, required the shaft hole to enter the fourth square from top right. The baffle was cut at center, and escutcheon placed at rear. The volume control was put at left, four squares down. Then a Farrand 10-G speaker was put inside with power amplifier.

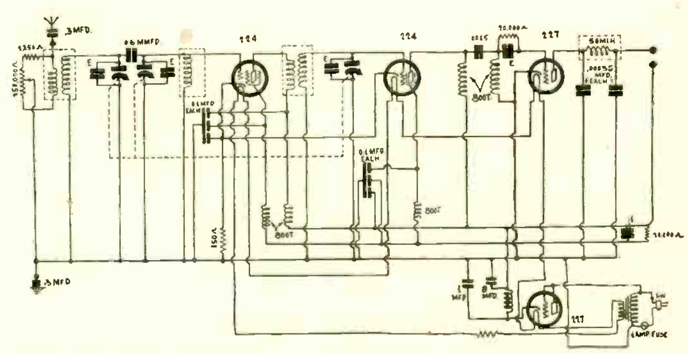
The tuning condensers have 3/8-inch diameter shafts, as distinguished from the more common 1/4-inch shafts. However, a reducing coupler (coupler takes 1/4-inch shaft) permits the moving of the scale farther from the tuning condenser, if such is the requirement. The same holds true of positioning the drive mechanism farther from the condenser, at the opposite end.

For Other Console Installations

Thus the drum dial model meets diverse requirements, including even the mounting of the drive close to the scale itself, preferably on the right-hand side of the scale, since most persons are right-handed. This is done by connecting a reducing coupler (X-8) to the condenser shaft, a 1/4-inch diameter flexible coupler to the extension coupler, a two-inch long shaft to one side of the flexible coupler, putting the drive on this shaft, the other end of the shaft through the scale hub.

Also for regular console installation the tuner may be at right and power amplifier at left, on separate chasses, the scale clearing the space between.





The Diamond HBD Tuner, using a drum dial. The B supply is built in. The 8 mfd. condenser is mounted inverted, between 227 rectifier and first RF tube, penetrating a socket hole.

LIST OF PARTS

Coils

One shielded antenna coupler for .0005 mfd. (15-75)
One shielded tuned impedance RF coupler for .0005 mfd. (75)
One shielded interstage screen grid coupler for .0005 mfd. (25-75)
Five 800-turn duo-lateral wound RF choke coils
One copper shielded 50 mlh radio frequency choke coil (SH-RFC)
One filament transformer for series heaters (FTSH)
One 30 henry choke (K-30)

Condensers

Two 1 mfd. condensers (POL-1)
One 8 mfd. electrolytic (C-8)
One 0.6 mmfd. Hammarlund fixed condenser (FC-6)
Four 100 mmfd. Hammarlund equalizers (EQ-100)
One three-gang Scovill .0005 mfd. tuning condenser, brass plates (SC-3G)
Four blocks, three 0.1 mfd. condensers in each block (SUP-31)
One .0015 mfd. fixed condenser (MICON-15)
Two .00035 mfd. fixed condensers (MICON-35)

Resistors

One 4.3 ohm fixed resistor, 2 ampere rating (CL-43)
One Electrad 150 ohm flexible biasing resistor (EL-150)
One 2,250 ohm fixed resistor (FR-225)
One 250,000 ohm potentiometer (POT-250)
Two .02 meg. pigtail resistors, 20,000 ohms (PGT-02)

Other Parts

One 9½x9½x2⅝ inch metal subpanel, with socket holes drilled (DHPT-SP)
Four UY sockets (YSO)
Two knobs (KB)
Four binding posts (for antenna, ground and output)
One AC shaft type switch (STSW)
One Hammarlund drum dial, 100-0, bottom up, with scale, escutcheon and drive
One 25-ft. roll of slide-back hookup wire (HW)
One AC cable (CAL)
One male plug (MP)
One 1 ampere fuse with holder

A Question and Answer Department conducted by Radio World's Technical Staff. Only Questions sent in by University Club Members are answered. Those not answered in these columns are answered by mail.

Radio University

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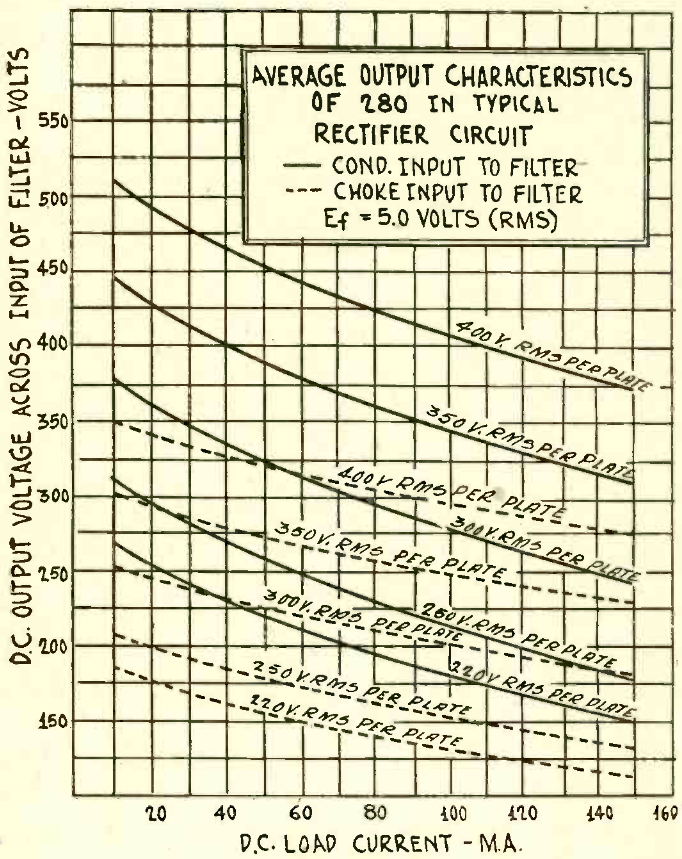

FIG. 898

A set of regulation curves for a 280 rectifier tube in a typical circuit, the curves including the resistance of the power transformer windings connected to the tubes, the resistance of the tube itself, and that of one choke.

Meaning of Regulation

WHAT is meant by the regulation of a transformer or a B supply? Does it have anything to do with a voltage control such as a rheostat in the circuit? If you have any curves illustrating regulation will you kindly publish them?—S. G. H.

By regulation is meant the change in output voltage with change in current drawn. If the voltage remains constant as the current changes the regulation is perfect, but if the voltage drops rapidly as the current increases the regulation is poor. The change in the voltage as measured at the output terminals is due to the resistance in the source of voltage, such as the winding of the transformer, the line, the B eliminator, or battery. When the regulation is perfect the internal resistance is zero. This is practically true of storage batteries and even of dry cell batteries as long as they are fresh. In Fig. 898 is a set of regulation curves for a 280 tube in a full-wave rectifier circuit. These curves include one choke coil. The dotted curves on this graph show a better regulation than the full curves because the voltage does not drop so rapidly as the current increases.

* * *

Determination of Bleeder Current

IN a B supply the bleeder current depends on the value of the resistance in the voltage divider. What is the basis on which the resistance and the bleeder current are determined?—C.F.L.

On common sense, mostly. If the receiver draws so much current that the B supply is operating near the maximum current that should be drawn when the bleeder current is not counted, one naturally decides on a resistance such that the bleeder current is as small as practical. If, on the other hand, the receiver does not take much current it is permissible to use a lower voltage divider resistance and so allow more bleeder current. The actual value of the voltage divider resistance is determined by the voltage across it and the current desired through the resistance. It is only the lowest section of the voltage divider which carries the bleeder current alone. The higher sections also carry plate current. This current must also be taken into account when determining the resistance values.

* * *

Volume Control Placement

YOU have explained that when the grid bias is increased or the screen voltage decreased to reduce the amplification in the receiver cross modulation is increased. If there is any way in which this can be avoided without resorting to different tubes will you kindly explain the method?—L. N. B.

There is only one proper place for the volume control, and that is in front of the first tube, either in the antenna circuit or the grid circuit of the tube. To decrease the output decrease the input. Perhaps the best device for doing this is a high resistance potentiometer. If this is put in the grid circuit make the resistance at least half megohm and connect it across the tuning condenser. The slider goes to the grid. If the potentiometer is connected in the antenna circuit you can make the resistance 30,000 ohms. This should be connected across the primary with the antenna going to the slider.

* * *

Reverse Feedback for Volume Control

AS I understand it, an automatic volume control is a device for feeding back direct current through a resistance in such a manner that the grid bias is increased when the current is increased. If this controls the volume automatically why would not reverse feedback do the same? That is, why could not a tickler be arranged so that it cause degeneration instead of regeneration?—W. H. J.

Reverse feed back will not control the volume automatically. It will simply reduce the sensitivity of the receiver, and it will do this for weak as well as for strong signals. It does not reduce the amplification in proportion to the strength of the signal, which an automatic volume control must do.

* * *

An Absurd Discrepancy

I HAVE a resistance coupled amplifier in which the plate coupling resistances are 100,000 ohms and the applied voltage is 180 volts. The tubes are *227*s. The grid bias is 13.5 volts. Tables giving the current for the *227* tube with 180 volts on the plate and 13.5 volts on the grid give six milliamperes. Now if I multiply the plate current by the plate load resistance I get 600 volts. But I apply only 180 volts in the plate circuit. Where does the excess voltage come from?—V. C. W.

The excess voltage comes entirely from your imagination. You assume that the plate current is 6 milliamperes just because the tables on the tube give this current. But you don't have 180 volts on the plate. According to your calculation you should have minus 420 volts on the plates. Suppose you connect a 100,000 ohm resistance in series with a 180 volt battery. What current do you get? You get 180/100,000, or 1.8 milliamperes. You canot get any more than that in the circuit. Indeed, you will get much less, for there is the internal plate resistance of the tube also. The fact is that you will not get more than about one milliampere. If you get that, the plate voltage will be 80 volts, for there will be a drop of 100 volts in the coupling resistance.

* * *

Measuring Mutual Inductance

PLEASE suggest a simple method of measuring the mutual inductance between two equal coils. I have in mind two coils used for intermediate frequency transformers with tuned primary and tuned secondary. I have a calibrated oscillator covering a rather wide range of frequencies. I should like to use this if possible.—C. D. C.

Mount the two coils in the position in which you want their mutual inductance. Then connect them in series and also connect a small condenser across the two. This forms a resonant circuit, the natural frequency of which you can measure with the oscillator. When you have found the frequency reverse the connections of the two coils under measurement, without disturbing their positions, and again measure the frequency. The tuning capacity in the two cases may be assumed to be the same, but the inductances will be different. If L is the inductance of each coil and M the mutual inductance between them, the inductance in one case, that for which the frequency is lower, is $2(L + M)$ and in the other, that for which the frequency is higher, is $2(L - M)$. If the two measured frequencies are F1 (low) and F2 (high), we have $(F1/F2)^2 = (L - M)/(L + M)$.. From this we can determine M in terms of the frequency ratio and the inductance of either coil. If we want to determine the value of L, we have to know the value of C, the condenser in question. Suppose this is 500 mmfd. Connect this across one of the coils and measure the natural frequency of the circuit formed. Let this be F3. Then $L = .0253/(F3)^2C$. If the frequency is measured in cycles and the capacity in farads, the inductance is given in henries. If this value of L is substituted in the preceding formula containing M, its value can be obtained in henries. This is not very simple but it does make use of your oscillator.

* * *

Intermediate Frequency Coil

I WISH to make intermediate frequency transformers to be peaked at 480 kc, using .00035 mfd. condensers and 100 mmfd. trimmers. I have some tubing 1.75 inch in diameter and a quantity of No. 32 double silk covered wire. How many turns should I use for the tuned windings? I plan to tune both windings and put them on different forms so that I can vary the coupling to get a band pass effect.—A. L. W.

Use 80 turns for each tuned winding. This assumes that you use .00035 mfd. and one-half of the trimmer condenser.

* * *

Superheterodyne Pointers

I WISH you would explain a peculiar phenomenon in my superheterodyne, a short-wave receiver. When I tune the oscillator the volume increases gradually, then the set suddenly stops playing, and as I turn the oscillator dial still further the signals suddenly come back. As I turn still further the volume decreases. The signals stop with a click and come back with another click.—A. S. W.

This phenomenon is what is called interlocking of the tuned circuits and is directly due to too close coupling between RF and oscillator tuned circuits. It may be that the pickup coil is too large and too closely coupled to the oscillating circuit. Or it may be that the intermediate frequency is not high enough. Again, it may be due to lack of by-passing of the battery leads. Regardless of the immediate cause, it is always due to too close coupling between the two tuned circuits. It is met more frequently when the intermediate frequency is relatively low, and for that reason it usually happens when the shorter waves are tuned in, because as the signal frequency increases the ratio of the intermediate frequency to the signal decreases, or the difference between the oscillator and RF frequencies decreases relatively. By-pass all common impedances, such as those of the batteries or B supply, grid bias resistors or grid batteries, and various leads used by both the oscillator and the RF tubes. Also put the two coils far apart or put shields between them. If these do not help, reduce the number of pick-up turns on the oscillator coil.

* * *

Variable Mu Tubes

IN THE February 28th issue you published a discussion of a variable mu screen grid tube. Is it not a fact that all tubes have variable amplification factors? What is there new about this G51 tube?—T. F.

It is a fact that the mu of all tubes varies a little with the plate voltage, but in the operating range the variation is so minute that it may be considered a constant. The G51, on the other hand, has an amplification factor that varies greatly as the grid voltage is varied, especially as the bias becomes high. Ordinary tubes have been designed geometrically so that the mu is to be a constant, while the G51 has been designed geometrically so that its mu will vary.

* * *

Scale Gives Resistance

IN THE February 28th issue you published a scale by means which resistance can be measured with the aid of a 0-1 milliammeter. In the paragraph just above "Using Higher Voltage" there is a formula which does not seem correct. I have tried to apply it and I cannot get the values you give. Is the error in the formula or in the computation? Can this scale be used also with a meter having a 0-.5 milliampere scale?—S. W. O.

There is a mistake in the formula. The last I should be in the denominator. The formula given just under "Calibration Formula" is correct. Solve this formula for Rx or else write the other one in the form $Rx = 1{,}500\ (1 - I)/I$. In this formula 1 stands for one milliampere and I stands for the meter reading in milliamperes. The scale cannot be used directly with a 0-.5 milliammeter.

* * *

Mounting Speaker in Wall

I HAVE a closet in which I keep my radio set and control it from another room. This closet is back of a wall in the living room and I have wondered if I could use the wall as a baffle by cutting a hole in the wall. The loudspeaker would then be in the closet with the set. I could make this hole so that I could also mount the remote control on the wall without adding to the defacement of the wall. I realize that the hole in the wall will not do the wall any good, but I am willing to do it if the arrangement would prove satisfactory. I could easily treat the hole so that the speaker would look like a picture.—W. H. C.

This would make the very best kind of baffle and if your set is capable of a quality to justify the large baffle there could be no serious objection from the electric or acoustic points of view. The esthetic features are for you to decide. One complication may arise. There may be considerable room resonance in the closet which would tend to mar the effect. But if the closet is filled with clothing and other sound-absorbing material this trouble should not be too serious. It could probably be remedied very easily by draperies around the back of the speaker. Try the speaker in the closet before you cut the hole in the wall. Watch for two things, room resonance or booming and howling. The howling would be due to microphonic troubles.

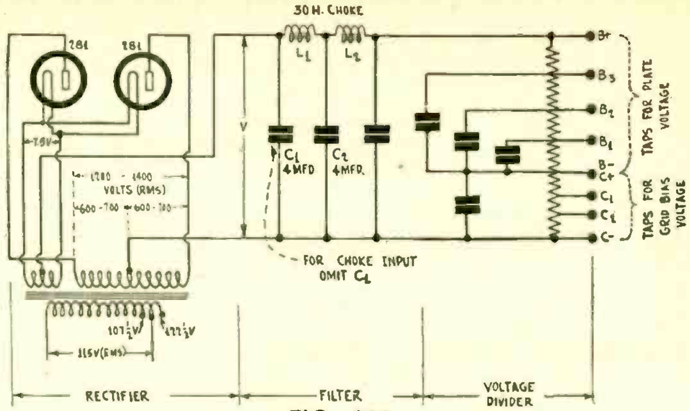

FIG. 899

The diagram of a full-wave rectifier using two 281 tubes. The resistances in the voltage divider must be determined from the current and voltage distribution required by the receiver.

IF Frequency of Superheterodyne

IS IT possible to find an intermediate frequency for a superheterodyne that will not bring in undesired radio signals? I have tried many frequencies in the broadcast band for a short-wave super, and also frequencies above the broadcast band, but there is always interference. What frequency do you suggest?—R. T. Y.

If it were not possible to find an intermediate frequency free of interference no superheterodyne would be practical. But there are many superheterodynes using different intermediate frequencies, and many of them are eminently practical. The only necessary condition is that the intermediate frequency selected should be lower than the lowest frequency which is to be received with the set. Strictly speaking, there is no frequency which is free from interference because the entire frequency spectrum from about 15,000 cycles to 30,000,000 cycles is occupied.

If there is a strong station operating on the frequency selected it is only necessary to shield the intermediate frequency amplifier from the signals of this station so that they cannot enter the amplifier. To make this practical, the intermediate frequency should be considerably lower than the lowest frequency to be received. For example, if the lowest frequency to be received is 550 kc, it would be all right to use 500 kc. However, it happens that there is considerable ship traffic on this frequency, and it is just as well to select a somewhat lower frequency to avoid this possible interference. But 480 kc should be low enough. Most commercial superheterodynes now use 175 kc, which is all right for broadcast reception, although it may be too low for short-wave work. The reason for putting the intermediate frequency below the lowest frequency to be received is to avoid the direct heterodyning when the IF and the signal frequency are the same.

* * *

Electrolytic Condensers

WHAT determines the voltage rating of electrolytic condensers? What determines the capacity?—L. W.

The voltage rating depends on the forming voltage. The higher the forming voltage the thicker the gas film which forms the dielectric. The capacity also depends on the forming voltage because the thicker the dielectric the lower the capacity. The capacity is also directly proportional to the area of the opposing electrodes. There is a limit to the forming voltage beyond which the plates will not form. This depends on the material. For aluminum it is around 400 volts.

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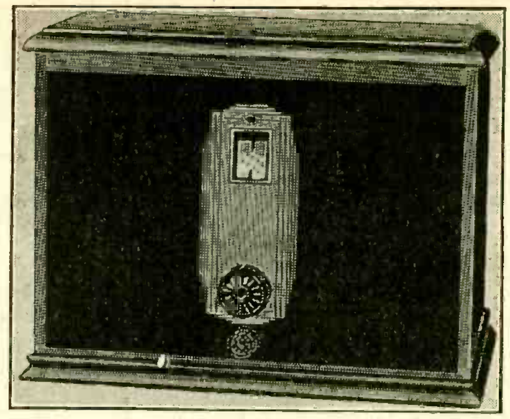

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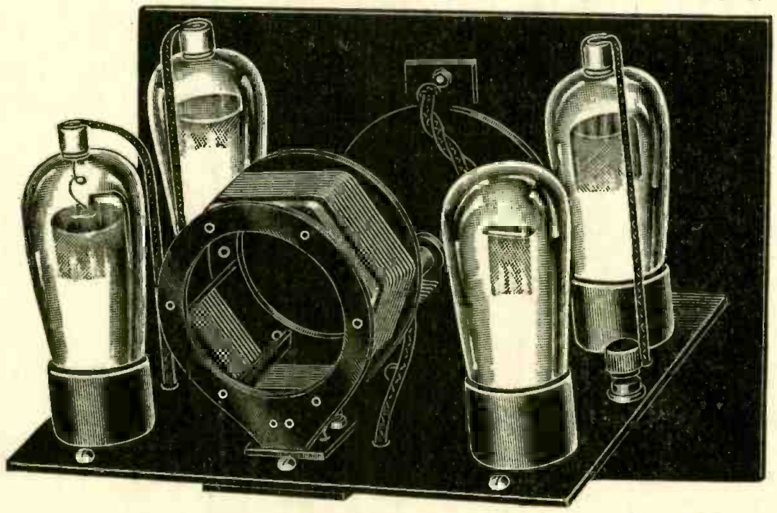

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Tuning is easy, and is free from body capacity or trickiness common in regenerative circuits, because the rotor of the Hammarlund tuning condenser used in this de luxe converter is grounded, and the coil is far from the hand.

As for appearance, it is of the highest possible order of attractiveness, providing eye appeal of the first magnitude, due to the use of Formica bakelite front and subpanel, National modernistic dial and Hammarlund condenser, united in an aesthetic and symmetrical layout. The DX-4 unit was designed by J. E. Anderson and Herman Bernard.

The assembly is utterly rigid and self-supporting, requires no cabinet, and may be installed above or below a broadcast set in the extra space of a console, or a separate cabinet can be supplied.

The sensitivity of this converter, used with only a fair broadcast set, whether tuned radio frequency, Neutrodyne or superheterodyne, is extremely high, and users report the consistent direct reception of European, Canadian, Central and South American short-wave stations, as well as relays of program stations in the United States, and code from the world over—right in their own homes—providing a thrill even for jaded radioists.

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The ever-widening variety of short-wave transmissions from all over the world makes the possession of the Polo DX-4 Converter a virtual necessity to full radio enjoyment.

Connections and Tuning

TO tune in the broadcast band, 200 to 600 meters, use the largest coil (rear center socket as you view front panel toward you).

Thus you can use this converter for remote control tuning of broadcast waves, as well as short waves.

To tune in waves below 200 meters, remove the large coil, and put in that socket coils of successively smaller size. A total of four coils enables reception of from 10 to 600 meters.

The complete parts for the de luxe all-wave triple-screen grid converter, exactly as specified by the designers, can be supplied, or a wired model. Connections are simple.

No knowledge of radio technique nor any skill in tuning is required, as there are only two external connections to make. You do not have to search for a method of obtaining "B" voltage from your broadcast receiver, as the DX-4 has its own complete power supply. Here are the two connections:
(1)—Remove aerial wire from the antenna post of your receiver and connect aerial instead to the antenna post of the converter.
(2)—Connect a wire from the remaining post on the converter to the vacated antenna post of the broadcast receiver.

Do not remove ground from set. The converter is automatically grounded.

To operate the converter, tune your set to the highest frequency to which it will respond, (lowest wavelength), usually zero numerically, above 1,500 kc in frequency. However, if your set is more sensitive at any other setting, and experience will guide you, use the most sensitive setting, always with volume control of the receiver at position for maximum volume. You must select a setting of your receiver dial that does not bring in broadcasts direct, for these will come through even with the converter attached. In fact, the converter works as a booster, or pre-amplifier, for your set.

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